Medals of Creation

FIRST LESSONS IN GEOLOGY,

AND

THE STUDY OF ORGANIC REMAINS.

BY

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INCLINED STRATA OF MILLSTONE GRIT, CRICH HILL.

IN TWO VOLS.—VOL. II.

CONTAINING

Fossil Cephalopoda, Crustacea, Insects, Fishes, Reptiles, Birds, and Mammalia.

WITH NOTES OF GEOLOGICAL EXCURSIONS.

SECOND EDITION, ENTIRELY REWRITTEN.

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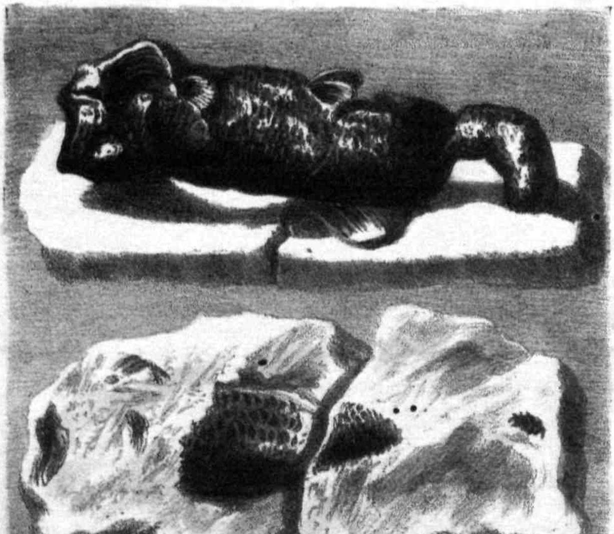
Pl. 2.



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DESCRIPTION

OF THE

FRONTISPIECE OF VOL. II.

PLATE II.

Illustrative of the mode of developing Fossil Fishes in Chalk.

OSMEROIDES MANTELLI: A FOSSIL SMELT; from the *Chalk*, Lewes.
See page 626.

(*One-third natural size.*)

Fig. 1.—The two corresponding surfaces of a block of Chalk split asunder. The irregular oval lines, seen on each surface, are the only apparent indications that the stone contains an extraneous body.

2.—In this figure the two pieces represented above are shown cemented together; care having been taken that the oval markings on each surface were accurately adjusted. The chalk has been chiselled away in the supposed longitudinal direction of the enclosed extraneous body, and part of the scaly surface of a fish has been thus brought to light. A portion of chalk has also been removed towards both ends, with the view of ascertaining the extent and direction of the fossil; and at each place indications of its presence are visible.

3.—Represents the specimen completely developed. It proves to be a fish almost perfect, lying on its back, with the body uncompressed, the mouth open, the arches and opercula of the gills expanded, and the dorsal, pectoral, and ventral fins entire. The caudal fin, or tail, is imperfect. The original is nine inches long, and is one of the most extraordinary fossil fishes ever discovered. It belongs to the Salmon family, and is allied to the *Osmerus*, or Smelt; it is now in the British Museum. We thus perceive that the oval markings on the surface of fig. 1 were occasioned by the section of the scales covering the cylindrical body of the fish (see p. 627). A magnified view of one of the scales is figured *Lign.* 185, *fig.* 4, p. 567.

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THE

MEDALS OF CREATION.

CHAPTER XII.

FOSSIL CEPHALOPODA; COMPRISING THE BELEMNITIDÆ, NAUTILIDÆ, AND AMMONITIDÆ.

LIGN. 140. FOSSIL SEPIA OR CUTTLE-FISH: ⅓ nat. (*M. D'Orbigny.*)
Solenhofen.
(KELÆNO* SPECIOSA. *Count Münster.*)
* The impression of the body, head, and arms, with their clasps.

THE molluscous animals named *Cephalopoda* (from their organs of prehension being arranged around the upper part

* *Kelæno* (one of the Furies) = Acanthoteuthis (Wagner); probably identical with Belemnoteuthis, which also has ten sub-equal arms.—*Mr. Woodward.*

of the body) are the most ancient, numerous, and interestin of this division of animated nature ; and their fossil remain comprehend the most varied and striking forms of extinc beings that occur in the sedimentary strata, from the earlies Secondary to the latest Tertiary formations. The livin species are but a feeble representation of the countles myriads which swarmed in the ancient seas ; yet they afford important assistance in developing the characters o the numerous extinct genera, whose relics abound in the strata, and will continually be presented to the observation of the collector. It is therefore necessary to enter somewhat in detail on the structure of these beings, that the student may obtain a correct idea of the nature of the curious fossils to which the mineralized remains of the durable parts of these animals have given rise, and whose origin has but lately been correctly ascertained. The body of these mollusca is either enclosed in a shell, as in the *Nautilus*, or contains a calcareous or cartilaginous part, as in the *Sepia*, or cuttle-fish ; they have a distinct head, and eyes as perfect as in the vertebrate animals ; complicated organs of hearing ; and a powerful manducatory apparatus, surrounded by arms serving for prehension. They have below the head a tube which acts as a locomotive instrument to propel the animal backwards, by the forcible ejection of the water that has served the purposes of respiration, and which can be thrown out with considerable force by the contraction of the body. The figures 1 and 6, *Lign.* 142, are views of a naked (that is, *shell-less*) cephalopod, showing the arms, eyes, and a pair of fins, for swimming. The Cephalopoda, thus endowed with powerful organs of locomotion, traverse the seas unrestricted, and are seen in groups of myriads in the midst of the ocean, and only appear periodically near the shores. Their fossil remains consist of—

1st. The external shells ; which are generally symmetrical, and either straight (as in *Orthoceras*, *Lign.* 155) ; arched or

bent (as in *Crioceras*, *Lign.* 160); spiral (as in *Turrilites*, *Lign.* 163); or involute,* and simple (as in the *Argonaut*), or divided, by smooth or foliaceous partitions, into chambers or air-cells, connected by a hydraulic tube or siphuncle (as in *Nautilus*, *Lign.* 149 and 150, and *Ammonites*, *Lign.* 156 and 157).

2dly. The internal horny or calcareous support, called *osselet*, and its appendages.† (*Lign.* 143.)

3dly. The ink-bladder, with its inspissated contents, termed *sepia*.

4thly. The mandibles of the mouth, or beaks, called *Rhyncholites*. (*Lign.* 150, *fig.* 1.)

5thly. The soft parts of the animal in the state of molluskite; impressions of the head and tentacula, and remains of the clasps or curved hooks of the arms of some species (see *Lign.* 140 and 145).

These several parts are generally found separate, but they sometimes occur in their proper relative position, and from such examples the nature of the original may be determined.

The Cephalopoda‡ are divided into two orders, according to the number of their organs of respiration, or gills; namely, the *Dibranchiata*, or those which have two gills, (called also *Acetabulifera*, from their arms being furnished with rows of little cups or suckers;) and the *Tetrabranchiata*, which have four gills, or branchiæ, and very numerous arms without suckers.

* *Involute*, as applied to the shells of Cephalopoda, implies that the inner whorls are embraced by the outer turn or whorl; *convolute*, the inner turns apparent, or exposed; *evolute*, the whorls coiled in one plane, but not touching each other; *revolute*, the extremities bent inwards.

† The *bone* or *shell* of the Cuttle-fish, the friable part of which, reduced to powder, forms *pounce*, is the *osselet* of that cephalopod.

‡ The best systematic account of the Cephalopoda and Gasteropoda, both recent and fossil, yet published, is contained in the first part of the very valuable Manual of Mollusca, by Mr. S. P. Woodward, of the British Museum.

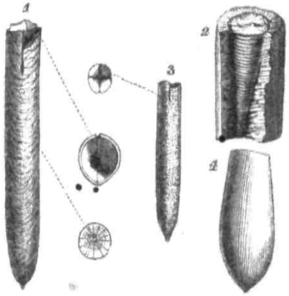
FOSSIL DIBRANCHIATE CEPHALOPODA.

The *Argonaut*, or Paper Nautilus, whose elegant fragile shell is too well known to require description, is the only living genus of this Order, in which the animal is protected by a hard calcareous external covering. This shell is symmetrical, and convoluted on a vertical plane, and consists of but one cavity or chamber. The other genera are naked, and possess an internal chambered shell (as in the recent *Spirula*), or some modification of such an apparatus. The last chamber or cell of these enclosed shells is too small to admit any part of the body of the animal; a character by which the fossil species of this Order may be distinguished from those of the other order. Others have a horny or calcareous osselet, as the bone of the Cuttle-fish, and pen of the Calamary or Sea-pen (see *Bd.* pl. 28); and in an appendage of this kind a conical chambered shell is contained in many of the fossil genera, hereafter to be noticed. These animals have eight arms, with the addition in some genera of two long tentacula, which are furnished with rows of suctorial disks or cups, called *acetabula* (see *Lign.* 142, *figs.* 1, 6).

These naked Cephalopoda, devoid of any external defence, possess a very extraordinary means of escape from their enemies. They are furnished with a bag or bladder, containing a dark fluid resembling ink in appearance, which they have the power of ejecting into the surrounding water upon the approach of danger; and by the obscurity thus induced, they foil the pursuit of their adversaries: the Nautilus and other cephalopods, protected by a large external shell, are destitute of such an apparatus. The deep brown colour, *sepia*, was formerly prepared from the fluid of the ink-bags of different species of Cuttle-fish; a similar substance secreted by extinct naked Cephalopoda, as we shall presently demonstrate, is found in a fossil state. These preliminary remarks on the organization of the recent ani-

mals will prepare us for the investigation of the extinct species. We will first notice those remarkable fossils, called *Belemnites*, or thunder-stones.

Belemnite (from a supposed resemblance to the head of a dart or javelin). *Lign.* 141 to 144. Among the innumerable relics of an earlier world, which swarm in the sedimentary deposits, there are perhaps no fossil bodies that have excited



Lign. 141. Belemnites: ½ *nat.* *Chalk and Oolite.*

Fig. 1.—Belemnitella mucronata. *Chalk. Brighton.* On the right of the figure is a view of the aperture, and a transverse section.

2.—Portion of a Belemnite, containing the internal conical chambered shell, called *phragmocone*. *Oolite.*

3.—Belemnitella quadrata. *Beauvais, France.* The quadrangular cavity is shown in the upper figure on the left. (*M. D'Orbigny.*)

4.—Belemnites dilatatus. *Lower Greensand* (*Néocomien*). *France.*

more curiosity, and given rise to so many fruitless conjectures as to their nature and origin, as the Belemnites.* These are long, cylindrical, or fusiform fossils, more or less pointed at one extremity, and having at the other and larger end a conical cavity, which is either occupied by a chambered

* See Park. Org. Rem. vol. iii. p. 122.

shell, or filled up with the material in which the fossils are imbedded. Their substance is like fibrous calcareous spar, varying in colour from a dark brown to a light amber; many are transparent, others nearly opaque. When broken transversely they present a radiated structure (*Lign.* 141, *fig.* 1); and a minute central cavity, or axis, is seen to extend through the whole length of the solid portion of the stone (see *Lign.* 142, *fig.* 5.). A longitudinal section (*Lign.* 142, *figs.* 4 and 5) shows the conical cavity in the upper part, and that the shaft consists of a series of concentric layers. Such are the characters of these fossils in the examples of most frequent occurrence.

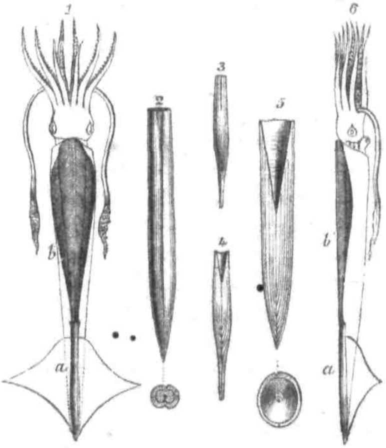
The Belemnites vary in size from the small, delicate, transparent species, *Lign.* 142, *figs.* 3 and 4, to massy opaque specimens, several inches in circumference, and from ten to twenty inches in length. They present also considerable variety of form; some are regularly cylindrical, as in *Lign.* 141, *fig.* 1; others broad and flattened, as in *fig.* 4; or subfusiform, as in *Lign.* 142, *figs.* 3 and 4. The small end is slender and pointed in some belemnites, and in others is obtuse, or rounded, with a projecting point. In many there is a longitudinal groove or furrow on the ventral aspect; and some species have a furrow on each side, as in that represented in *Lign.* 142, *fig.* 2.

But the fossils above described are only a part of the original structure of the Belemnite. When in a perfect state, the cavity seen in *Lign.* 142, *fig.* 5, is occupied by a chambered conical shell, called the *phragmocone*, composed of a series of shallow concave cells, of a nacreous or pearly substance, which are pierced by a siphuncle at the margin: see *Lign.* 141, *fig.* 2.

The parts of the BELEMNITE at present known consist of—

1st. The spathose osselet, or *guard*, having at the larger end a conical cavity, called the *alveolus*, as in *Lign.* 141, *fig.* 1, and *Lign.* 142, *fig.* 5.

2dly. A conical, chambered pearly shell, termed the *phragmocone*, which is situated in the *alveolus* (as in *Lign.* 141, *fig.* 2).



LIGN. 142. BELEMNITES: ½ *nat.*

Fig. 1.—A front view of the supposed animal of the Belemnite, by *M. D'Orbigny.* *b.* denotes the osselet, to the base of which the *Belemnite, a,* is attached.

2.—BELEMNITES BIPARTITUS; the figure below shows the form of the aperture. *Neocomian Formation. France.* (*M. D'Orbigny.*)

3.—BELEMNITES LISTERI (G. A. M.); *from the Galt. Ringmer.*

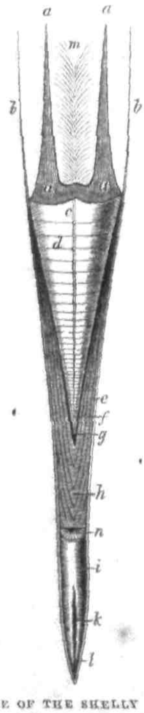
4.—A longitudinal section of B. LISTERI.

5.—BELEMNITES SEMICANILICULATUS: a longitudinal section; the figure below is the aperture of the *alveolus.* *From the Firestone* (*Craie tufeau*) *of France.*

6.—A side view of fig. 1.

3dly. The horny prolongation of the *capsule* (the outer investment of the *guard*), called the *receptacle*, as in *Lign.* 143.

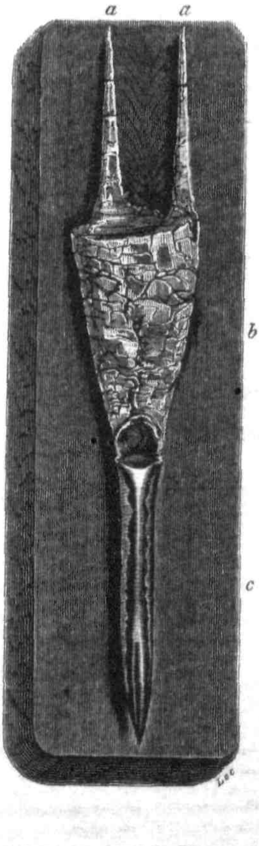
4thly. The *ink-bag*, and its inspissated fluid, *sepia*; (*Bd.* pl. 44′, figs. 7, 9.)



LIGN. 143. THE STRUCTURE OF THE SHELLY PARTS OF THE BELEMNITES PUZOSIANUS.

Oxford Clay. Christian Malford. (½ *nat. size.*)

a, a. The dorsal basilar processes of the phragmocone.
b, b. Upward extension of the attenuated osselet.
c. Siphunculus.
d. Phragmocone: the transverse lines indicate the septa.
e. The capsule or outer investment of the guard.
f. The distal part of the phragmocone.
g. The alveolus or cavity in the guard.
h. Vertical section of the guard.
i. The solid part of the rostrum or guard.
k. The sulcus or groove on the ventral aspect of the rostrum.
l. Shows the continuation of the capsule, in section, continued from *e.*
m. Diverging parallel striæ observable between the dorsal processes of the phragmocone.
n. Transverse section of half the diameter of the radiated structure.



LIGN. 144. VERY PERFECT SPECIMEN OF BELEMNITES PUZOSIANUS.

Oxford Clay. Christian Malford, Wilts. ($\frac{1}{2}$ *nat. size.*)

a, a. Basal processes of the phragmocone.
b. The phragmocone.
c. The rostrum or guard of the osselet, containing the apex of the phragmocone in its upper part.

The invariably radiated crystalline structure of the Belemnite has evidently resulted from the peculiar organization of the original osselet, which is formed of thin concentric laminæ, of very minute prismatic trihedral fibres, arranged at right angles to the planes of the successive layers.*

From the obvious analogy of the structure above demonstrated with that of the recent dibranchiate Cephalopoda, several eminent naturalists inferred that the animal of the Belemnite was closely related to the existing types; and the late Mr. Miller, in a communication to the Geological Society of London, gave a restored figure of the original, which, as modified by M. D'Orbigny, is represented *Lign.* 142, *figs.* 1 and 6. The indefatigable and successful researches of the Rev. Dr. Buckland have confirmed the general correctness of this restoration. In the Lias of Dorsetshire two specimens of the Belemnite, with its chambered shell and horny or pearly receptacle, still retaining the ink-bag and its contents, have been discovered, and were figured in the Br. Treatise (*Bd.* pl. 44′, 44″). A third specimen, showing the ink-bag, is in the British Museum.

The ink-bag of the Belemnite is very small, as might be expected, from the extent to which it is protected by a chambered shell. The mandibles or beaks of the Belemnite are supposed to have been horny, as in the other naked Cephalopoda; since no calcareous beaks have been found associated with their remains.

"The Belemnite having the advantage of its dense, but well-balanced internal shell, must have exercised the power of swimming backwards and forwards, which it possessed in

* The Belemnitic shell presents the same arrangement of its constituent layers as the Pearl-mussel, Pinna, and other *Aviculidæ*, viz. the outer layer is prismatic-cellular, the inner nacreous: the first is formed by the free margin of the mantle, the second by the visceral ("peritoneal") part of the mantle.—*Mr. Woodward.*

common with the modern decapod (*ten-armed*) Dibranchiata, with great vigour and precision. Its position was probably more commonly vertical than in its recent congeners. It would rise swiftly and stealthily to infix its claws in the belly of a supernatant fish, and then perhaps as swiftly dart down, and drag its prey to the bottom and devour it. We cannot doubt at least but that, like the hooked Calamaries of the present seas, the ancient Belemnites were the most formidable and predacious of their class."—OWEN.

The Belemnites of the oolitic limestones frequently contain the phragmocone, either filled with calcareous spar, or with its cells empty. In the clays the horny sheath or receptacle is sometimes found pressed flat and extending above the alveolus of the osselet, and has often a thin coat of nacre of a pearly lustre, but it is more commonly detached.

The Belemnites abound in the Lias, Oolite, and Chalk, and have not been discovered in any other deposits; there are nearly thirty British species, some of which are restricted to the Chalk, and others to the Oolite and Lias.

A few characteristic forms are represented, *Lign.* 141 and 142, in order to illustrate the three groups which, according to M. D'Orbigny, are peculiar to the grand divisions of the Cretaceous formation.

1. BELEMNITELLA MUCRONATA. *Lign.* 141, *fig.* 1.—The name *Belemnitella* is given to those Belemnites which have a slit, or crevice, on the anterior margin of the alveolus or cavity, and two lateral impressions. The surface is sometimes granulated, and often has vascular markings, produced by the investing integument of the living animal. The form of the aperture is shown in the middle dextral figure; and the radiated structure, as seen by a transverse section, in the sketch.

This species is abundant in the *White Chalk*, particularly

in certain localities in Norfolk and Devonshire. It is more frequent in the chalk of Kent than in that of Sussex; and in the cretaceous strata around Brighton, than in those near Lewes. I have never been able to detect the least vestige of the phragmocone, or chambered shell, in the alveolus. This Belemnite is occasionally imbedded in flint nodules; and such examples possess the calcareous crystalline structure of the chalk and limestone specimens. In the chalk of Ireland, the Belemnites which have been corroded, or perforated by marine borers (*cliona*), are often injected with flint; and if the calcareous substance be removed by immersion in dilute hydrochloric acid, exquisite siliceous casts may be obtained (see also page 403). It is not unusual to find flints with a cavity, occasioned by the solution and removal of the calcareous guard, and having a siliceous conical cast of the alveolus, occupying the upper part of the interspace. The reader will recollect that the pulley-stones of the Derbyshire Encrinites were produced by a similar process (see p. 285, vol. i.).

The American cretaceous sands abound in a species of Belemnitella, nearly related to *B. mucronata.*

2. Belemnites Listeri. *Lign.* 142, *fig.* 3.—This small elegant Belemnite has two lateral grooves, and is generally as transparent as amber; it has frequently a nacreous or calcareous pellicle partially investing the guard. It seldom exceeds two inches in length. It is abundant in, and peculiar to, the Galt, or blue marl of the Chalk, and is constantly associated with the Inocerami, previously described as common at Folkstone, Bletchingly, Ringmer, and other localities of that deposit. The Red Chalk of Norfolk contains the same species (*Min. Conch.* tab. 589).

3. Belemnites dilatatus. *Lign.* 141, *fig.* 4.—This species is distinguished by its flattened form, and by the longitudinal furrow being situated on the margin opposite

to the siphuncle of the phragmocone, instead of being on the same side, as is most usual. It is supposed by M. D'Orbigny to be characteristic of the Neocomian beds, or lowermost division of the Shanklin Sand.

4. The Chalk-marl contains a Belemnite of a more elongated form than those above described, the apex gradually tapering to a point, with a slight double furrow on each side. It is named *B. lanceolatus* (*Sow. Min. Conch.* tab. 600, figs. 8, 9), and is very common in the marl-pits at Steyning, Clayton, and Hamsey, in Sussex.

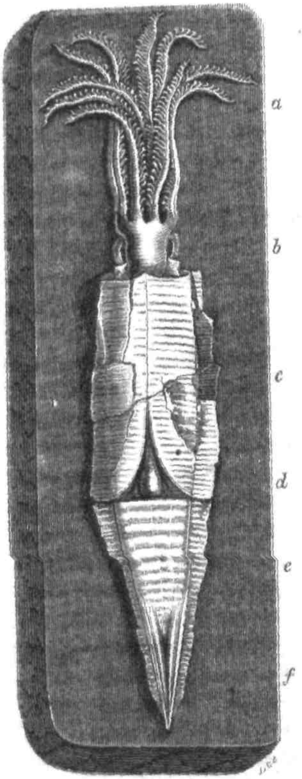
At the base of Golden Cap Hill, near Charmouth, there are two strata of marl-stone observable on the shore, which are literally paved with Belemnites. Great numbers of these fossils have Serpulæ and other extraneous shells attached to them, a proof that the ink-bags and other soft parts of the mollusks had decomposed, and that the guards had lain uncovered at the bottom of the sea.

M. De Koninck has discovered in the Devonian limestone of Belgium, at Couvin and Visé, a small fossil body which closely resembles in form and structure the rostrum or guard of a belemnite; it is, however, too fragmentary to admit of positive detemination.*

BELEMNOTEUTHIS† (J. C. Pearce). *Lign.* 145.—Within the last few years much additional knowledge has been obtained regarding the nature of the extinct Cephalopoda, by the discovery in the Oxford clay, at Christian Malford, not only of several examples with the receptacle and ink-bag in their natural relative positions, but also with the remains and impressions of the mantle, body, tentacula with their hooks, and the fins!

* Bulletin de l'Académie Royale de Bruxelles, tome x. No. 3. p. 207.

† For the history of this interesting Cephalopod consult Phil. Trans. 1848, and 1850; Ann. Nat. Hist. June 1850; Petrif. p. 459, &c.

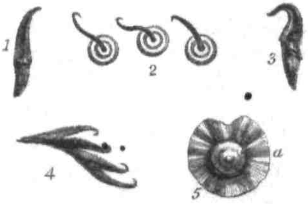


LIGN. 145. BELEMNOTEUTHIS ANTIQUUS. (*Pearce.*)

Oxford Clay. Christian Malford. (½ *nat. size.*)

a. The uncinated arms and tentacles.
b. Remains of the head and eyes.
c. The mantle, with indications of fins.
d. The pigmental sac or ink-bag.
e. The osselet: the transverse lines indicate the septa of the phragmocone, which is covered by a horny sheath or capsule.
f. The solid terminal apex of the osselet.

Certain argillaceous strata of the Oolite, as well as of the Lias, appear to have been peculiarly favourable for the preservation of the muscular tissue and integuments, and in many specimens of BELEMNOTEUTHIS, the arms, the large sessile eyes, the funnel, a great proportion of the muscular parts of the mantle, remains of the two lateral fins, the ink-bladder and duct, and the phragmocone, are well displayed, as in the beautiful example, *Lign.* 145, for the drawing of which I am indebted to S. P. Woodward, Esq., of the British Museum. (See also *Lond. Geol. Journ.* pl. xv. and xvi.)



LIGN. 146. HORNY RINGS AND HOOKS OF BELEMNOTEUTHIS ANTIQUUS.

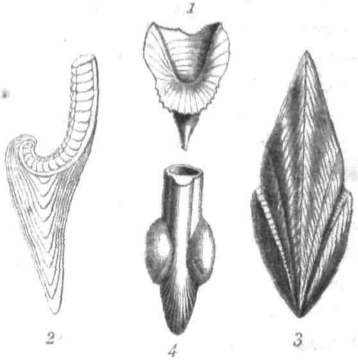
Fig. 1, 3.—Detached hooks (*natural size*).
2.—Three hooks with attached horny rings: from a specimen in the possession of Mr. Cunnington.
4.—Part of one of the arms, showing four hooked spines.
5.—Transverse section of the distal part of the osselet of BELEMNOTEUTHIS, exposing the apex of the chambered shell in the centre, surrounded by the radiated osselet, *a* (*magnified four diameters*).

From the extraordinarily perfect condition of the Belemnoteuthis here figured, which of itself exemplifies the essential parts of its structure, a brief description will suffice. The body is of an elongated form, with a pair of lateral fins, two large sessile eyes, eight uncinated arms, and a pair of armed tentacles; each arm was furnished with from twenty to forty pairs of hooks, placed alternately. Like the *Sepia* it had a pigmental sac or ink-bag, which is generally found filled with the inspissated secretion. The inferior part of the body is of a conical form, and contains a brown horny

osselet, with a siphunculated phragmocone, that terminat in a guard or rostrum of a fibrous structure.

[In the recent genus *Onychoteuthis*, the *tentacles* alone a armed with claws; *Enoplo-teuthis* has claws both on tl arms and on the tentacles, but the latter are long and feebl and the hooks are confined to their extremities. The extinc *Belemnoteuthis* (like the *Acanthoteuthis* of Solenhofen, *Lign* 140) had eight nearly equal arms, the dorsal pair bein rather smaller than the rest; each arm was furnished witl twenty to forty pairs of hooks, forming a double, alternatin row. The tentacles were not longer than the arms, and like them had a double series of hooks extending from their bases to the points. In all essential points of structure, the *Belemnoteuthis* is most nearly related to the Calamaries (*Teuthidæ*), but, in consequence of the prolongation of its pointed shell posteriorly, the fins become lateral (as in *Sepiola* and *Sepia*), instead of terminal. Whilst the complicated (chambered) structure of its shell, and the peculiar character of the *tentacles*, show that it must be regarded as a type distinct from and equal in importance to the Calamaries. It cannot be doubted that the *Belemnite* and *Conoteuthis* present similar conditions of the soft parts; and the four genera will form the Family BELEMNITIDÆ. The normal position of these animals in the sea is *horizontal*, whilst that of the Nautiloid genera must have been *vertical*, with the head downwards.—*Mr. Woodward.*]

The fossils which have afforded this unexpected and highly interesting illustration of the nature of the extinct animals of this Order have been obtained by closely examining the shales in which they abound, and, before removing the solid osselet, carefully searching the surrounding stone for traces of the more perishable parts. The attention of the collector can scarcely be too often directed to the necessity of examining the surrounding matrix before extricating a fossil from its bed.



LIGN. 147. OSSELETS OF EXTINCT DIBRANCHIATE CEPHALOPODA.

(*Woodward, Manual*, p. 76, pl. 1 & 2.)

Fig. 1.—Belosepia sepioides; ½ *nat. Eocene. Bracklesham.*
2.—Spirulirostra Bellardii; ⅔ *nat. Miocene. Turin.*
3.—Beloteuthis subcostata; ¼ *nat. Lias. Wirtemberg.*
4.—Beloptera belemnitoides; ⅔ *nat. Eocene. Bracklesham.*

BELOPTERA (*Bd.* pl. xliv. fig. 15. *Min. Conch.* tab. 591).—Under this name Mr. Sowerby figures and describes a very curious fossil, from the London Clay at Highgate, which seems to hold an intermediate place between the Cuttle-fish and the Spirulirostra. The guard, which is of an oblong form, with an obtuse apex, has the structure of the osselet of the Sepia, and contains in its upper part a phragmocone the cells of which are very narrow. In strata of the same age, in France, three species have been discovered by M. Deshayes. I allude to these shells, that the attention of the collector may be directed to the search after other examples in our tertiary deposits.

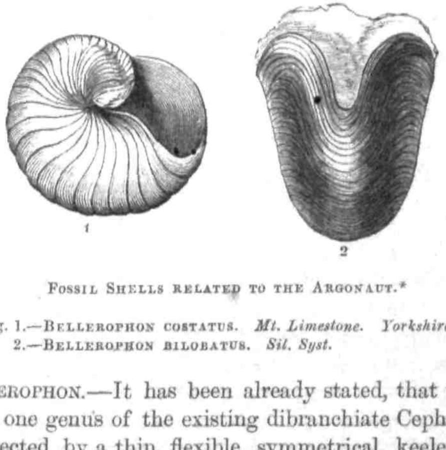
FOSSIL CALAMARY, OR SQUID. GEOTEUTHIS* (*Bd.* pl. xxviii

* Geoteuthis has hooks on its arms; but, being a Calamary (Teuthid), it would probably have *unequal* arms.—*Mr. Woodward.*

xxix.).—The common Calamary (*Loligo vulgaris*) is so often seen on our shores, that its general aspect must be familiar to all who frequent the sea-side. In this animal, the osselet, or internal support, is a cartilaginous elongated body, which, from its form, is called Sea-pen (*Bd.* pl. xxviii.); and even this delicate structure is found in a fossil state. In the Lias of Lyme Regis, Miss Mary Anning first discovered specimens of *Sea-pens* in juxtaposition with the ink-bag, as in the recent Calamary; and subsequently many similar examples have been found, both in England and on the Continent. Dr. Buckland has given some exquisite figures of these fossils; and his collection contains a matchless series of these most interesting organic remains. In some specimens the ink-bag and its tube or duct, but little compressed, are occasionally met with, having a brilliant nacreous pellicle, the remains of the sheath, attached to the surface. The ink-bag is sometimes of considerable magnitude; specimens have been found at Lyme Regis nearly a foot in length.* The circumstance of the ink-bags being generally full of sepia admits of the inference (as Dr. Buckland with his wonted acumen remarks), that these individuals died suddenly; for their living analogues reject the inky fluid upon the least approach of danger. The perfect condition of the bag proves also their instantaneous enclosure in the deposit, for the distended membrane would otherwise have burst from decomposition, and the contents would have escaped. The fossil marine reptiles, the Ichthyosauri, &c., with which these fossils are associated, present similar phenomena, as we shall hereafter have occasion to remark, and strengthen the probability, that swarms of the inhabitants of the Liassic ocean were suddenly destroyed, and imbedded, on the area now occupied by their remains.

* The large ink-bags figured by Dr. Buckland (Br. Tr. vol. i. pp. 372—379, pl. xliv.') belonged to the great Geoteuthis Bollensis, of Schuble.—*Mr. Woodward.*

In the cream-coloured limestone of Solenhofen, so rich in organic remains of the highest interest (*Wond.* p. 578), the soft parts of naked Cephalopoda have also been discovered. I have figured, *Lign.* 140, a beautiful specimen obtained by the late Count Münster, which exhibits an imprint of the body, the arms and tentacles being represented by ten double rows of horny hooks, which precisely resemble those of Belemnoteuthis. M. D'Orbigny supposes that the original animal closely resembled a recent decapod called *Enoploteuthis leptura*.



LIGN. 148. FOSSIL SHELLS RELATED TO THE ARGONAUT.*

Fig. 1.—BELLEROPHON COSTATUS. *Mt. Limestone. Yorkshire.*
2.—BELLEROPHON BILOBATUS. *Sil. Syst.*

BELLEROPHON.—It has been already stated, that the animals of one genus of the existing dibranchiate Cephalopoda are protected by a thin, flexible, symmetrical, keeled shell, convoluted on a vertical plane, and having but one chamber—this is the *Argonaut*, or *Paper Nautilus*, an inhabitant of the Mediterranean. This animal belongs to the Octopoda, or those which have eight arms; and in one pair of these processes the extremities expand into broad and thin membranes, by which the delicate, elastic, calcareous envelopement, or shell,

* Some naturalists consider the Bellerophon to be allied to the Carinaria (*Heteropod*).

is secreted. These membranes usually encompass the shell, and meet and overlap each other along its keel; and by them chiefly the shell is retained in its position. When these membranes are withdrawn, or the animal dies, the shell, having no muscular connexion with the soft parts, readily separates from the body. Hence the doubts so long entertained as to the relation between the animal of the Argonaut and its shell, but which are now set at rest; the observations on the living animal by Madame Power, and the anatomical demonstrations by M. Sander Rang, having removed the obscurity in which the subject was formerly involved.

In the Silurian, Devonian, and Carboniferous deposits there are several species of a genus of shells, the animals of which are by some considered to have been analogous to the recent Argonaut. It is named BELLEROPHON. I have figured two species; one from the Mountain Limestone, *Lign.* 148, fig. 1; the other from the Silurian System. There are about thirty British species, most of which are of small size; some of them are keeled, others have a slight dorsal depression, as in fig. 1. and many have the back rounded, and the sides lobed, as in *Lign.* 148, fig. 2.

FOSSIL TETRABRANCHIATE CEPHALOPODA.

I am not aware of the existence of any British fossils analogous to Spirula (*dibranchiate*); for the minute fossil polythalamia, formerly referred to this class, are now known to have belonged to animals possessing an organization altogether different, as we have already explained (see p. 369). I therefore proceed to notice the fossil remains of those *Cephalopoda* which were furnished with an external shell having its cavity divided by cells, which are perforated by a hydraulic tube or siphuncle; and of which group the recent NAUTILUS is the type.

The appearance and structure of the recent shell are familiar to every one; a correct knowledge of the nature of the original animal has, however, been obtained but very recently. In its general characters the animal of the Nautilus, which is an inhabitant of the seas of hot climates, resembles the naked Cephalopoda; it possesses four *branchiæ*, or gills, and numerous hollow arms and retractile tentacula. Its head is furnished with a muscular flattened disk, which serves as an operculum to the shell when the animal is retracted. The beaks are horny, and coated at their tips by calcareous matter. It has no ink-bag, and is destitute of fins or other organs for swimming. The body occupies the ample outer cell of the shell, to which it is firmly attached by two lateral muscles; and it has a siphuncle, that passes from the posterior part of the animal through the shelly tube, and by which communication is maintained with the entire series of cells or chambers. The siphuncle is provided with a small artery and vein, and traverses the entire series of chambers, thus maintaining the vitality of the shell. Mr. Edwards considers that "it may be looked upon as an elongated cæcum, and that it is not under any circumstances used by the animal as a hydrostatic balance." *

LIGN. 149.

NAUTILUS POMPILIUS IN ITS SHELL.

a. The animal, occupying the last or body chamber of the shell.
b. The shell cut vertically through the middle, and showing the air-chambers and the siphuncle.

* The reader interested in this subject should consult the *Memoirs* by M. Valenciennes, Mem. de l'Inst.; M. Vander Hoven, in the Proceedings of the Zoological Society; Prof. Owen's *Memoir on the*

Upon making a vertical section of the shell, the inner volutions are exposed, and the cavity is seen divided at regular intervals into cells, by smooth, concave, nacreous septa; these vary in number according to the age of the individual; there are about thirty-five in an adult specimen. The partitions are pierced in the *centre* by a shelly tube, which traverses each cell to within a short distance of the next partition; and this tube is rendered a continuous channel in the living animal, by the membranous siphuncle. This series of air-chambers constitutes an apparatus which renders the Nautilus nearly of the same specific gravity as the surrounding water, and enables it to rise to the surface of the sea, or sink to the bottom, by a very small amount of muscular exertion. The Nautilus swims, like the Cuttle-fish, by expelling the water from its respiratory chamber; the walls of which are very thick and powerful muscles.

From this very general description of the only living representative of the numerous genera of tetrabranchiate Cephalopoda, which swarmed in such prodigious numbers in the ancient seas, we may pass to the consideration of the fossil Nautili, and their related congeners. Our remarks must be limited to the genera that will serve to demonstrate the most important modifications of structure, and explain the nature of the fossil remains of this extensive class of extinct beings.

The genera into which these shells are distributed are founded upon the mode in which the shell is coiled, its form, the character of the partitions or septa, and the situation of the siphuncle. A little reflection will enable the student to understand the principles of this classification. The essential character of all the shells of this class, is to have an external chamber larger than the inner chambers, and which contains the body of the animal; to be divided in-

Pearly Nautilus, Mr. Gray's paper in the An. Nat. Hist., Mr. Edward's Monograph in the Palæont. Soc., and Mr. Woodward's *Manual*.

ternally into different compartments, by partitions (concavo-convex, with the concavity outwards); and to have a pipe or tube extending from the outer open chamber to the innermost cell. They are divided into three groups or families.

1. The Nautilidæ (*Bd.* pl. xxxi.): in these the septa are smooth, or but slightly undulated, and the siphuncle either traverses the centre of the cell-partitions, or is situated towards the inner margin or turn of the spire.

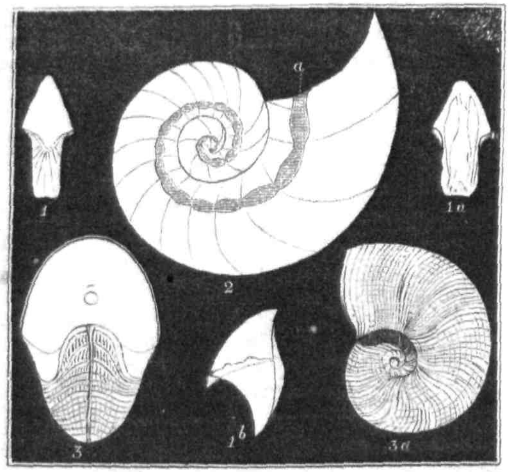
2. The Orthoceratidæ (*Lign.* 155): in these the siphuncle is complicated in its structure; it is central or lateral; the septa are smooth. (*Woodward's Man. Moll.* p. 87.)

3. The Ammonitidæ (*Bd.* pl. xxxv—xlii.): in these the septa are more or less waved, and their margins foliated or crenated, that is, indented; and the siphuncle is situated at or near the outer margin.

In the Nautilus, the shell is convoluted on the same plane, in spiral whorls, all of which are contiguous, and the siphuncle is central.

The British strata contain about sixty species of *Nautili.* The Tertiary formations have yielded five or six; the Cretaceous a like number; the Lias and Oolite ten or eleven; the Carboniferous about thirty species; and the Devonian two species. In the London Clay a large and beautiful species is abundant (*Nautilus imperialis. Min. Conch.* tab. i.), having the shell very commonly entire; but the outer opaque coat frequently flakes off, and exposes the pearly or nacreous internal layer. The septa generally retain their original nacreous structure, and the cells are either occupied by clay or marl, or are partially filled or lined with calcareous spar, brilliant pyrites, or other mineral matter. These Nautili are often found constituting the nuclei of the

septaria, or clay nodules, with which this deposit abounds.* The small species, *N. centralis* (*Ly.* fig. 179), and *Nautilus* (*Aturia*) *ziczac* (*Wond.* p. 247), occur in the same strata.



LIGN. 150. FOSSIL NAUTILI. *Chalk marl.*

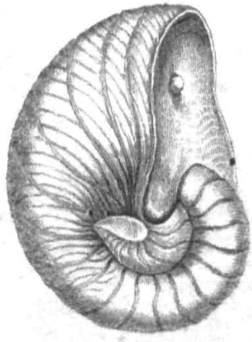
Fig. 1.—BEAK OF A NAUTILUS, (*Rhyncolite.*) Back view.
1a.—Anterior view of the same.
1b.—Profile of the same.
2.—Vertical section of NAUTILUS PSEUDO-ELEGANS. *Hamsey.*
a. The siphuncle.
3.—Front view of N. DESLONGCHAMPSII. (*M D'Orbigny.*) *Hamsey.*
3a.—Lateral view of the same.

The London Clay of the Isle of Sheppey and of the coasts of Hants and Sussex is productive of these fossils.

In the White Chalk near Lewes, casts of several very large Nautili have been found; but shells of this genus are

* Three other well-marked species are figured and described by Mr. Edwards (Monog. Pal. Soc.) from the English eocene strata: viz. *N. Sowerbyi*, *N. urbanus*, and *N. regalis*.

more abundant in the lower division, the *Chalk-marl*. A large and beautiful species, *Nautilus elegans* (*Min. Conch.* tab. 116), is not unusual in the marl-pits near Lewes, Clayton, Steyning, &c. and may be considered as characteristic of that portion of the Cretaceous deposits. The first specimen discovered (*Foss. South D.* tab. xx) was from the marl-bank immediately at the foot of the mound on which stands



LIGN. 151. NAUTILUS ELEGANS.

Lower Chalk. Lewes. (½ *nat. size.*)

the church of HAMSEY, a little hamlet on the north of Lewes; a spot from which I obtained numerous other cephalopodous shells, at that time unknown as British species. The collocation of fossils at Hamsey is similar to that observable in the quarries at St. Catherine's Mount, near Rouen. These remains only occur as casts, no vestige of the shell remaining; but sections will sometimes show the situation of the siphon, its tube being filled with a different material from that which occupies the cells. This is exemplified in the section of a smaller species (*N. pseudo-elegans*, *Lign.* 150, *fig.* 2), in which the channel of the

siphon is filled with a dark-coloured marl, *a*; the lines formed by the section of the smooth septa are also shown.

LIGN. 152. NAUTILUS SAXBYI. *Lower Greensand.*

In the same lignograph, *fig.* 3, a front view and profile ot another chalk-marl Nautilite are figured.*

In the Chalk, as well as in many other calcareous deposits, the *shells* of the Nautili, Ammonites, &c. are very rarely preserved; even the internal septa are often dissolved, and the stony casts, moulded in the cells, remain

* The student will find a section of the shell of the recent Nautilus a very instructive object of comparison, in the investigation of the fossils of this family.

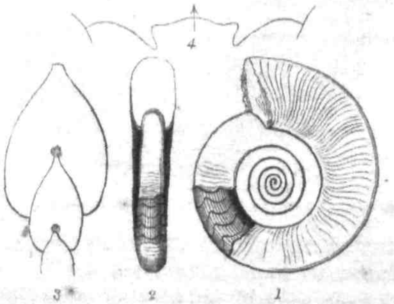
distinct, and readily separate (*Lign.* 153). An entire series, from the innermost cell to the outer chamber, may some-

1 2

LIGN. 153. CASTS OF CHAMBERS OF NAUTILUS AND AMMONITE. (½ *nat.*)
Fig. 1.—Cast in calcareous spar of a chamber of NAUTILUS.
From the London Clay.
2.—Cast of a chamber of AMMONITES EXCAVATUS.
From the Coral Rag.

times be obtained (in the Coralline Oolite); forming, as it were, a dissected model of the internal structure.* The beaks or mandibles are occasionally found fossil (*Lign.* 150, *fig.* 1).

CLYMENIA (*Lign.* 154, *Ly.* fig. 406).—This genus belongs to the Nautilidæ, and is peculiar to the Devonian deposits.



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LIGN. 154. CLYMENIÆ: ½ *nat.* *Devonian.*
Fig. 1.—CLYMENIA SEDGWICKII.
2.—Front view of the same.
3.—Vertical section of C. STRIATA, showing the siphunculus on the inner edge of each septum.
4.—*Suture of C. STRIATA.*

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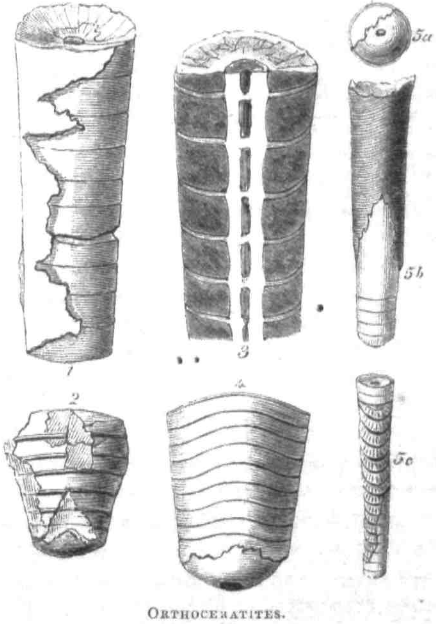
* Bd. pl. xlii. fig. 1: see also plates xxxi. to xliii., for illustrations of Nautilites.

It differs from the allied genera in the siphuncle being situated on the inner margin of the septa. The shell is discoidal, and the septa are very slightly lobed. At Elbersreuth, near Bareuth, in the N. E. of Bavaria, the Devonian strata abound in these shells; thirty-five species have been found, the greater number being peculiar to that locality.

In England they are chiefly found at South Petherwin, Cornwall, and in the Devonshire marbles. (*See Phillip's Pal. Foss. Devonshire.*)

ORTHOCERAS (straight shell), *Lign.* 155.—The shells of this genus may be described as Nautili uncoiled and extended in a straight line. They are straight, elongated, chambered shells, with smooth and gently undulated septa, which are concave towards the opening or upper part, and have the siphuncle either central, or not far removed from the centre. The *Orthoceratites* more especially belong to the ancient Secondary strata. They first appear in the Silurian, and abound in the Devonian and Carboniferous. They vary in size from a few inches to several feet in length, and eight or nine inches in diameter; and in form, from a slender elongated cone, to a short, massy, almost spherical figure, with a contracted orifice. Some examples have been noticed with upwards of sixty cells. Mr. Sowerby figures and describes *O. giganteum* (*Min. Conch.* tab. 246), from Scotland, as exceeding seven or eight feet in length; and I discovered on the beach at Brighton, where it had probably been brought by some vessel, among ballast, a fine fragment of the same species, indicating as great a magnitude. Several species are figured, *Lign.* 155, to show the structure and appearance of these fossils. The casts of the separate cells are often found. The section, *fig.* 3, from the red marble of Devonshire, beautifully displays the situation of the siphuncle, and the lines of the septa. The shelly siphuncle, which is moniliform (*bead-like*), or dilated at each

chamber, is replaced by white spar; and the membranous internal tube is filled with a dark substance, probably molluskite.



LIGN. 155. ORTHOCERATITES.

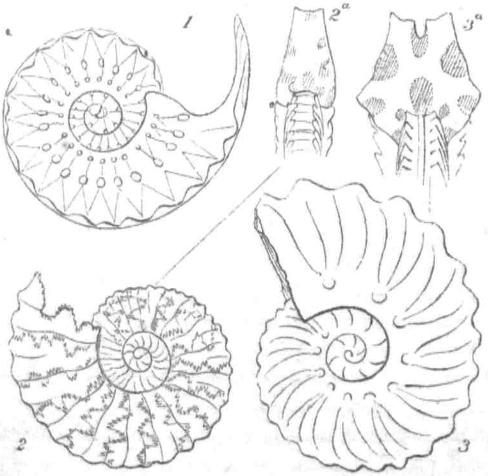
Fig. 1.—ORTHOCERAS STRIATUM. (*Min. Conch.*) *Devonian.*
2.—ORTHOCERAS CONICUM. *Whitby. Carboniferous.*
3.—Vertical section of an *Orthoceras*, showing the central siphon, and the chambers. *Devonshire.*
4.—ORTHOCERAS LATERALE. *Carb.* (*Min. Conch.*)
5.—ORTHOCERAS GREGARIUM. (*Murch. Sil. Syst.*)
a. One of the septa.
b. A portion covered at the upper part by the shell.
c. The lower part of the same specimen, displaying the septa.

There are some species in which the internal tube, as well as the external, is calcareous, and the two are connected at regular intervals, by radiating, hollow processes. These

Orthoceratites have been principally obtained from the Silurian limestones, at Lake Huron; they also occur in Ireland. Mr. Stokes, who first investigated their structure, has arranged them in a distinct genus, with the name of *Actinoceras* (*radiated-horn*).*

Slabs of reddish Devonian limestone, containing Orthoceratites, may be seen in some of the pavements at Hampton Court, and in Chelsea College, which when wet present excellent sections of the enclosed shells.

AMMONITIDÆ.—The AMMONITES, or *Cornua Ammonis* (so called from a supposed resemblance to the horns engraven



LIGN. 156. AMMONITES FROM THE CRETACEOUS FORMATION.

Fig. 1.—AMMONITES VARIANS. *Chalk-marl. Hamsey.*
2.—AMMONITES DUFRENOYI.
2a.—Shows the keel and septum of the same.
3.—AMMONITES LAUTUS. *Galt. Folkstone.*
3a.—Keel and septum of the same.

* See Geol. Trans. second series, vol. v. p. 708.

on the heads of Jupiter Ammon), are among the most common and well-known fossils of the British secondary strata. In some districts, as in Yorkshire and Somersetshire, where the *Ammonites* abundantly prevail, they were noticed in very remote times. Local legends, ascribing their origin to swarms of snakes turned into stone by the prayers of some patron saint, are still extant, and are perpetuated by the name of *snake-stones*, by which these fossils are provincially known. The Lias, near Whitby, in Yorkshire, contains immense numbers of two or three species, one of which (*Am. bifrons*) is figured in *Lign.* 127, *fig.* 7, and another in *Lign.* 157.

Lign. 157.
Ammonites communis.
Lias. Whitby.

The shells comprehended in this family are either spiral, involute, arched, or straight; their septa are deeply lobed, and have the margins foliated. The siphuncle is dorsal, as shown by the notch in the cast, *Lign.* 156, *fig.* 3 *a*. Several hundred species have been described; they are divided into genera which are characterized by essential modifications in the direction of the spire, and the inflections of the septa. Thus, in the *Ammonites, Lign.* 156, the spire is involute, and all the turns contiguous; in *Crioceras* (*curved-horn*), *Lign.* 160, *fig.* 2, evolute; in *Scaphites,* incurved at both extremities, *Lign.* 162; *Hamites*, bent like a siphon, or hook, *Lign.* 161, *fig.* 1; *Turrilites,* spiral, round a vertical axis, *Lign.* 163; and in *Baculites,* straight, *Lign.* 161, *fig.* 2. New genera are continually being added, to embrace modifications of structure which appear to be too important for specific distinctions. I will endeavour to render this arrangement more clear to the student by the following definitions.

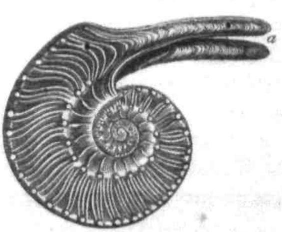
A straight tube, or horn, of an elongated conical figure, tapering to a point, and having its cavity divided by transverse partitions, which septa are not straight, but undulated, and their edges, which fit into the walls of the tube, deeply wrinkled, and the whole series pierced by a pipe running along near the outer margin, would be the model of the shell termed *Baculites*, *Lign.* 161, *fig.* 2, (*Bd.* pl. xliv. fig. 3;) which may be regarded as a straight Ammonite. A similar shell, gently arched or curved, would be a *Toxoceras*, *Lign.* 160, *fig.* 1; the same tube, bent upon itself, like a siphon, into unequal limbs, not contiguous, a *Hamites*, *Lign.* 161 (*Bd.* pl. xliv. fig. 10); bent and approximate, or anchylosed in a straight line, *Ptychoceras*, *Lign.* 161, *fig.* 4; partially convoluted, the whorls contiguous, and the free end recurved, *Scaphites*, *Lign.* 162; the same form, but the spire not contiguous, *Ancyloceras*, *Lign.* 160, *fig.* 3; spirally twisted around an axis, *Turrilites*, *Lign.* 163 (*Bd.* pl. xliv. fig. 14); coiled, but the turns not touching each other, *Crioceras*, *Lign.* 160, *fig.* 2; lastly, coiled up in the form of a disk, all the turns being contiguous, AMMONITES.

AMMONITES. *Lign.* 156, 157, 158.—Shell discoidal, more or less compressed, whorls of the spire contiguous, and often visible; septa lobed, their margins deeply sinuated; aperture symmetrical, border or lip thickened, often notched and auriculated. Siphuncle dorsal.

The student will be able readily to distinguish Ammonites from Nautili by attention to the above definition. The situation of the siphuncle, the foliated or wrinkled edges of the septa, as shown in the cast, *Lign.* 156, *fig.* 2; and when these characters are wanting, the arched ribs and elevations, as in *figs.* 1 and 3, will serve as discriminating features. Like the fossil Nautili, the Ammonites most commonly occur as casts, the shell having been dissolved. Sometimes these consist of semi-transparent calcareous spar, the cast of each cell being distinct, but held together by the inter-

locking of the foliations of the septa; such examples are of great beauty and interest (see *Bd.* pl. xlii. figs. 2, 3); they most frequently occur in the limestones of the Oolite. The siphuncle is often preserved, even in the chalk specimens, in which all traces of the shell are lost. In a large Ammonite from near Lewes, not only the shelly siphuncle remains, but even the internal membranous tube, converted into dark molluskite. Separate portions of similar siphuncles occur in the chalk, and have been mistaken for tubular shells.

The outer lip, or margin of the aperture, is occasionally found entire. In some species there is a dorsal process, as in a very common Chalk Ammonite (*A. varians, Lign.* 156, *fig.* 1), which extends far beyond the margin; in other species, from the Oxford Clay, there are long, narrow, lateral appendages, (*Lign.* 158.) In the collection of S. P. Pratt, Esq., there is a small Ammonite, from the Inferior Oolite of Normandy, in which these processes meet over the aperture, leaving only a circular aperture towards the back of the shell (where the siphuncle of the animal would be situated) and a narrow fissure on the side next the involute spire. The specimen is unique, and can scarcely be regarded as a normal form.* (*Mr. Woodward.*)



LIGN. 158. AMMONITES JASON. ½ *nat*
Oxford Clay, Trowbridge, Wilts.
a.—Lateral processes of the margins of the aperture.

From the small size of the cells of the Ammonites, particularly in those species which are of a depressed or flattened form, it was long doubted whether the outer chamber could

* M. Steenstrup has described a species of *Purpura*, which at the close of its life shuts up the aperture of its shell, with the exception of the respiratory siphon.—*Mr. Woodward.*

have been sufficiently capacious to contain the body of the animal; and it was supposed that these shells were internal, like the recent *Spirula*, or *Crosier*. But Dr. Buckland has clearly demonstrated, that the outer cell of the Ammonite, if restricted in breadth, is sufficiently ample in length to have contained the soft parts of a Cephalopod, equal in magnitude to the largest known specimens, its proportion to the chambered part being as considerable as in the Nautilus. The outer chamber often occupies more than half, and in some instances the entire circumference of the outer whorl (see *Bd.* pl. xxxvi.).

In certain argillaceous deposits, as the Galt, and the clays of the Lias, Ammonites with the shell preserved are abundant; generally the outer opaque layer is wanting, or adheres to the matrix when a specimen is removed, leaving only the internal nacreous, or pearly coat. Folkstone, on the coast of Kent, is celebrated for examples of this kind, which may easily be collected from the Galt, which forms the base of the cliffs, at Eastware Bay. Watchett, in Somersetshire, is equally rich in the pearly Ammonites of the Lias; entire layers of these beautiful organic remains occur in the limestones and in the shale exposed at low water.*

The shell of the Ammonite is generally thinner and more delicate than that of the Nautilus. However thin these shells may be, they are possessed of great strength of structure. Not only is the shell one continuous *arch*, but it is moreover provided with transverse arches or corrugated *ribs*, which, like the flutings on metal pencil-cases, and *corrugated sheet-iron*, greatly strengthen the thin material. These ribs are further subdivided, so as to multiply supports as the convexity of the shell enlarges, in a manner somewhat similar to the *groin-work* of vaulted roofs. The spines, tubercles, and bosses, which often arise from the ribs, are so

* A splendid group of these Ammonites may be seen in the Gallery of Fossils at the British Museum.

nany additions to the strength of the latter. The sides of he shell are also supported by the transverse plates forming he *septa*, or divisions of the chambers, and, as these plates re very sinuous where they meet the sides of the shell, they listribute their support over a considerable portion of the urface.* These complicated edges of the *septa* form the lelicate and intricate lines of foliation (*sutures*) seen on the asts of Ammonites (*Lign.* 156, *fig.* 2), Baculites (*Lign.* 61, *fig.* 3), Hamites, &c. In some species the shell is thick nd dense, as in the Ammonites of the Kimmeridge Clay ıear Aylesbury, in which one species (*Ammonites biplex, Min. Conch.* pl. ccxciii.) in particular abounds, and is very enerally invested with the shell, as perfect as if recent. The same Ammonite occurs in the Portland limestone above, n the state of casts, without any vestige of the shell. In ome strata the shell is replaced by calcareous spar; in thers by silex or flint.† In the pyritous clays and shales f the Lias, the shell and all its delicate internal mechanism re coated with or replaced by brilliant sulphuret of iron, rming the most exquisite natural electrotype imaginable. 'olished vertical sections of these fossils often exhibit the ner cells filled with transparent white calcareous spar; metimes with groups of crystals of sulphate of lime. The mmonites of the Galt, and of the Kimmeridge Clay, are lso frequently imbued with the same mineral.

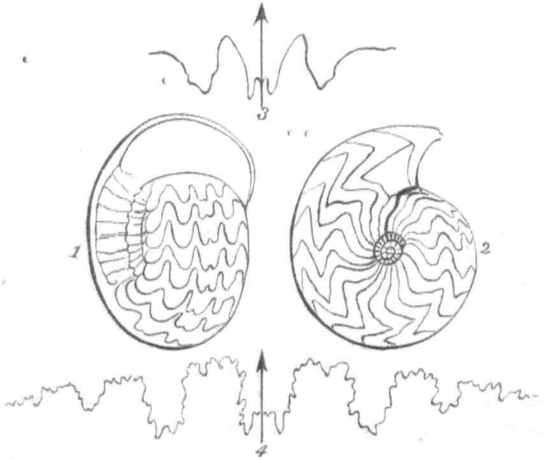
There are about two hundred identified species of Ammoite in the British strata, ranging through all the secondary rmations; they have not been found in the Tertiary eposits. They vary in size from half an inch to four feet diameter.‡

* See Bd. i. p. 339, &c.

† See an admirable figure of a chalcedonic specimen, exhibiting e foliated septa of an Ammonite, *Bd.* pl. xli.

‡ I have seen imprints of the large Chalk Ammonite, *A. peramplus* Iin. Conch. pl. ccclvii.), on the shore off Rottingdean, and Beachy ead, which indicated even larger proportions.

Certain species are restricted to particular formations, and are therefore oftentimes of essential aid in determining the relations of a deposit; for example, the *Galt* contains several species not found in the upper division of the Chalk; and in the Chalk-marl are species that have not been discovered in other strata. Certain Ammonites of the Lias are peculiar to that formation (as *A. Walcotii*, *Lign.* 127, *fig.* 7, p. 397; and *A. communis*, *Lign.* 157). Ammonites of species allied to those of our Middle and Lower Oolites have been discovered in strata in the Himalaya mountains, several thousand feet above the level of the sea.



LIGN. 159. GONIATITES. *nat.*

Carb. Syst.

Fig. 1.—GONIATITES LISTERI.
2.—GONIATITES STRIATUS.
3.—Outline of a suture of *Goniatite*.
4.—Outline of a suture of *Ammonites venustus*.

The *Arrows* in figs. 3 and 4 denote the direction of the dorsal line.

GONIATITES, *Lign.* 159.—From the numerous family of Ammonites, a separation has been made of a large division,

in which the margins of the septa are not deeply notched or foliated, and are destitute of lateral crenatures or denticulations, so that their outline always presents a continued uninterrupted line. The siphuncle is relatively small. The last or outer cell of the shell extends beyond one turn of the chambered part. The back is occasionally keeled, but in most species is round. In illustration of this genus, which is named *Goniatites*, I have selected two common species (*Lign.* 159) from the Carboniferous limestone, and annexed outlines of a suture (the edge of the septum) of a Goniatite, and of an Ammonite, for comparison. The importance of the separation of this type of Ammonites into a distinct genus, relates to the Goniatites being restricted to some of the older sedimentary strata; for although there are sixty British species, none of them have been observed above the Carboniferous system.*

In CERATITES the sutures are more simple than in the Ammonite, being lobed rather than foliated; and the alternate lobes have their edge crenulated or finely toothed. (*C. nodosus*, *Bd.* pl. xl.) This genus is found in the Muschelkalk and the Keuper formations of Europe and Asia.

Our limits will not permit us to extend this notice of the very numerous family of Ammonitidæ,† except to offer a few illustrations of some of the modifications in form to which we have already alluded, and which will assist the student in discriminating these fossil remains.

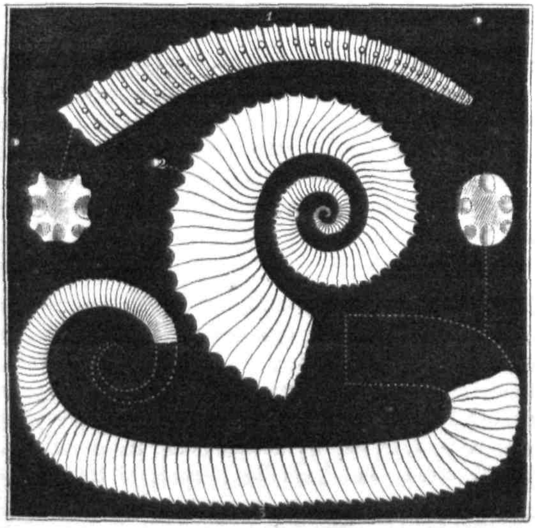
CRIOCERAS (*coiled-horn*), *Lign.* 160, *fig.* 2.—This shell differs from the Ammonites in the turns of the spire being

* *G. Henslowi*, *G. striatus*, and *G. sphæricus*, are figured in *Bd.* pl. xl.

† For further information, Dr. Buckland's Treatise, and the respective articles in the Penny Cyclopædia, may be referred to. Mr. Woodward's Manual should be consulted for the classification of the family, and M. D'Orbigny's Paléontologie Française for the illustration of species.

distant from each other. The siphuncle is continuous, and the septa are regularly divided into six lobes. I have found specimens of this genus in the Chalk-marl at Hamsey, and in the White Chalk, near Lewes (*Foss. South D.* tab. xxiii. fig. 9).

In the genus ANCYLOCERAS (*incurved horn*), *Lign.* 160, *fig.* 3, the whorls are separate, and, at first, spiral (like



LIGN. 160. SHELLS OF THE FAMILY AMMONITIDÆ.

Chalk and Greensand.

Fig. 1.—TOXOCERAS EMERICIANUM, and its septum. *Hamsey.*
2.—CRIOCERAS PUZOSIANUM. (*M. D'Orbigny.*) *Lewes.*
3.—ANCYLOCERAS FURCATUM, and its septum. *France.*

Crioceras); but afterwards the shell is prolonged, and then inflected at the large extremity, like a Scaphite, but the whorls are not contiguous.

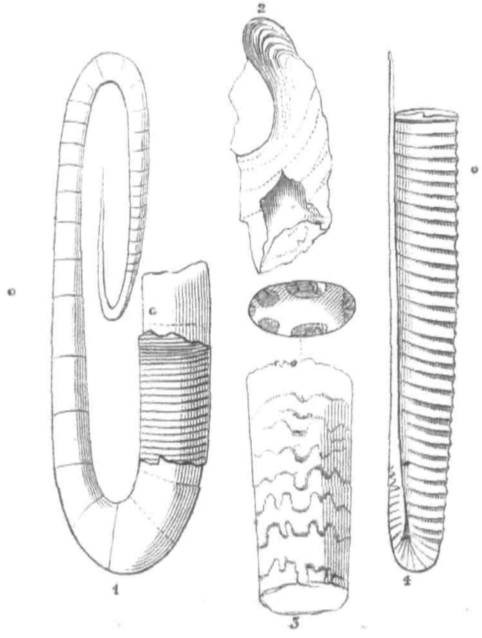
A very large species of *Ancyloceras* occurs in the Kentish Rag, near Maidstone, some specimens of which are eighteen inches in length. It is figured and described, by the name of *Scaphites Hillsii*, in the admirable Memoir of Dr. Fitton on the Strata below the Chalk (*Geol. Trans.* vol. iv. pl. xv.); the present genus was not then established. The Shanklin Sand in the Isle of Wight also contains a gigantic species, which is figured and described by Mr. J. D. Sowerby, in the *Geol. Trans.*, as *Scaphites gigas*. *Ancyloceras* occurs also in the Oolite.

In TOXOCERAS (*bow-horn*), *Lign.* 160, *fig.* 1, the shell is slightly curved, like a horn. Two or three species of *Toxoceras* are found at Hamsey. The tubercles, in the casts, are the bases of spines, with which the back of the shell was armed, as I have ascertained by examples examined in the rock (see *Foss. South D.* tab. xxiii. fig. 1). The specimens figured of the above two genera occur in the *Neocomian* strata of France.

HAMITES (*hook-shaped*). *Lign.* 161, *fig.* 1.—Shell involute, spiral, the turns not contiguous; spire irregular, elliptical; the large end reflected towards the spire. The term *Hamite*, proposed by the late Mr. Parkinson, was formerly given to all the fragments of subcylindrical chambered shells, that were bent, or slightly hooked; and the genera *Ancyloceras*, *Toxoceras*, &c., have been separated from them, by M. D'Orbigny. But from fossils recently obtained from Cretaceous strata in Pondicherry, and other parts of India, it seems probable that these genera will be found to merge into each other; at present it is convenient to keep up the distinction. The Hamites are distinguished from Ancyloceras, which they most resemble, by their elliptical, irregular spire.

PTYCHOCERAS (*folded horn*). *Lign.* 161, *fig.* 4.—This is another genus formed from the Hamites. The shell is bent

double in the shape of a siphon, and the limbs are united together. The specimen figured is from the *Neocomian* strata of the Lower Alps.



LIGN. 161. HAMITES, ETC. FROM THE CHALK-MARL.

Fig. 1.—HAMITES CYLINDRACEUS, with part of the shell. (*M. D'Orbigny.*)

2.—BACULITES BACULOIDES, with the mouth entire. *Hamsey.*

3.—Part of the stem of the same species, showing the sinuous septa. A detached *septum* is figured above.

4.—PTYCHOCERAS EMERICIANUM. (*M. D'Orbigny.*)

BACULITES (*staff-like*). *Lign.* 161, *figs.* 2 and 3.—This, as the name implies, is a straight, elongated, conical, chambered shell; the upper part is destitute of septa, and probably contained the body of the animal.

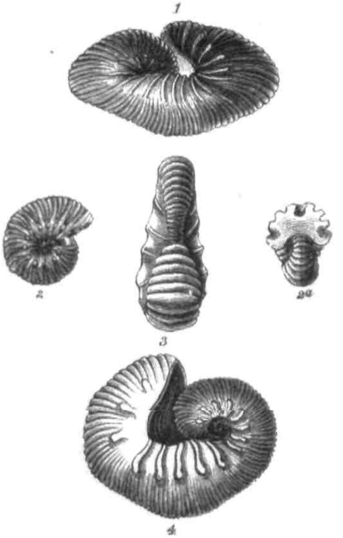
In my early researches in the Chalk-marl of Hamsey, I discovered numerous solid, oval, and cylindrical pipes of marl, with scarcely any vestige of organic structure, whose origin it was impossible to determine. At length I found the specimen, *Lign.* 161, *fig.* 2, which showed the perfect aperture of a chambered shell; and afterwards I found portions which displayed the foliated septa. (*Foss. South D.* tab. xxiii. figs. 5, 6, 7.) The Baculite, when perfect, is elongated *to a point; the septa are very numerous and foliated; the* siphuncle is situated on the margin. I have a splendid specimen from the Chalk of France, (collected by *M. Alex. Brongniart,*) which is composed of distinct casts of the cells, held together by the deep inflections of their margins, in the same manner as are the sparry casts of Ammonites, previously described.*

The Galt, near Folkstone, abounds in fossils of the above genera, principally of *Hamites;* and the nacreous substance of the shells is very often preserved. From the Chalk-marl near Dover, Southbourn, Ringmer, and Southerham, near Lewes, and from Clayton, near Hurstperpoint, in Sussex, I have obtained examples of several species.

Scaphites (*boat-like*). *Lign.* 162.—This name was given by Mr. Parkinson (*Org. Rem.* vol. iii. pl. x. See *Pict. Atlas*) to some small chambered shells from the Chalk and Shanklin Sand, of a boat-like form, with the inner whorls coiled up in a spire, and half hidden by the outer chamber, which becomes contracted and recurved on itself, is destitute of septa, and terminates in an oval or transverse mouth. The siphuncle is dorsal. An *Ancyloceras* closely coiled would be a Scaphite. Hamsey marl-pit yielded to my early researches the first Scaphites discovered in the British strata, together with Turrilites, and other cephalopodous shells, previously unknown in England.† The Scaphite is of an elliptical

* See Bd. pl. xliv. fig. 5. † Sow. Min. Conch. vol. i. p. 53.

form, the spire and the mouth approaching close to each other; the spire occupies about one-half of the shell. Except the thick outer lip or margin of the aperture, which is almost constantly found changed into pyrites, it is rarely that any vestige of the shell remains. The same mineral

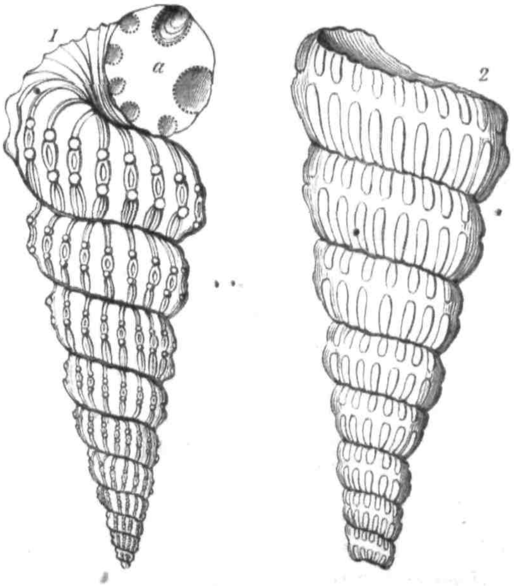


LIGN. 162. SCAPHITES. *Chalk-marl. Hamsey.*

Fig. 1 and 4.—SCAPHITES ÆQUALIS. (*Parkinson.*)
2.—Cast in pyrites of the spiral part of a SCAPHITE.
2*a*.—Front view of the same specimen.
3.—Front view of SCAPHITES ÆQUALIS.

constitutes casts of the spiral part; and these, when separated from the other portion, might be taken for Ammonites; see *fig.* 2. There are two varieties at Hamsey; one, with the surface covered by fine transverse striæ, which arise singly from the inner margins, and bifurcate on the dorsal part; *fig.* 1. The other is also striated, but has a row of

prominent ribs on the inner half of the broad central portion of the shell; *fig.* 4. Scaphites occur in the Upper Green Sand of Dorsetshire, and in the Chalk-marl in several places in England; and at Rouen, in France; and a large species, *S. Cuvieri*, has been found in New Jersey.



LIGN. 163. TURRILITES. *Chalk-marl.*

Fig. 1.—TURRILITES CATENATUS. (*M. D'Orbigny.*) *France.*
a.—One of the septa.
2.—TURRILITES COSTATUS. *Hamsey.*

TURRILITES. *Lign.* 163.—Shell spiral, more or less conical, coiled obliquely round an axis, and turriculated. Spire sinistral, whorls contiguous, apparent, with a perforated umbilicus. Edges of septa very sinuous. Siphuncle conti-

nuous, situated either on the external convexity, or near the suture at the base of the wreath.

The discovery of three species of these elegant shells rewarded my researches in the little marl-pit at Hamsey, already noticed, and were the first examples of the genus found in England.* Like the Ammonites, Scaphites, Hamites, &c. with which they are associated, the TURRILITES of our Chalk-marl seldom possess any traces of their shells. The specimens are solid and tolerably sharp casts, with occasional indications of the septa, and more rarely of the siphunculus. They vary in size from two or three inches to two feet in length; and are frequently more or less elliptical, from compression. The three species which generally occur in the Sussex and Kentish chalk, are *T. costatus*, *Lign.* 163, *fig.* 2; *T. tuberculatus* (*Foss. South D.* pl. xxiv. fig. 7), characterised by its four rows of tubercles; and *T. undulatus* (*Foss. South D.* pl. xxiv. fig. 8), the wreaths of which are ornamented with plain, slightly undulated, transverse ribs. These are all reversed, or *sinistral* shells; that is, the spire is twisted to the left, the aperture being on the right hand of the observer when the shell is placed on its apex, as in *fig.* 1. Several other species of Turrilites occur in the Chalk of France,† one of which, *T. catenatus*, is represented *Lign.* 163, *fig.* 1.

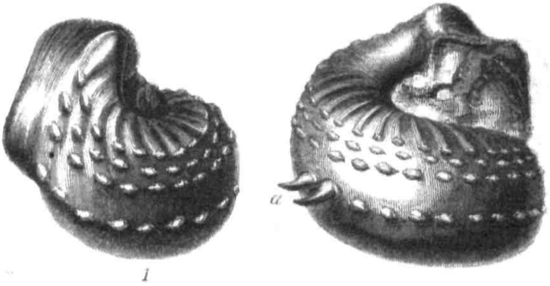
Some of the Turrilites attain a considerable magnitude. The largest found in England is a specimen of *T. tuberculatus* (*Min. Conch.* tab. lxxiv.), from Middleham, in the parish of Ringmer, near Lewes; when perfect, it must have been full two feet in length: it consists of six wreaths, the siphuncle, in the state of pyrites, appearing in three or four; portions of the nacreous internal layer of the shell remain.‡ In some specimens in my possession, the form of the aperture, and

* Sow. Min. Conch. tab. xxxvi.

† See M. D'Orbigny's Paléontologie Française.

‡ This specimen is now in the British Museum.

the termination of the columella, are distinctly shown; as in the fine example the last whorl of which is represented in *Lign.* 164.



LIGN. 164. TURRILITES TUBERCULATUS, (*Bosc.*) *nat.*

Chalk-marl, Lewes.

Showing the form of the aperture, and the spinous tubercles. The specimen is a cast in indurated chalk-marl; the last wreath only is figured.

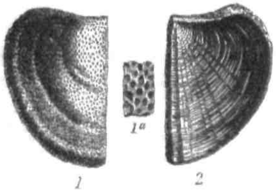
Fig. 1.—Posterior view, exhibiting the expanded outer lip, and the obtuse termination of the columella.
2.—Front view, showing the form of the aperture.
a.—Two tubercles, bearing spines.

The Chalk-marl of Lewes, of the Sussex coast, and of the cliffs near Dover, and the Upper Green Sand of Dorsetshire, have yielded the principal British specimens of this genus. Several species occur in the lower cretaceous strata, at St. Catherine's Mount, near Rouen, associated, as in England, with Scaphites, Hamites, and other allied genera.*

APTYCHUS, Meyer. (Trigonellites, *Parkinson.*) *Lign.* 165.—Associated with the remains of Ammonites in several localities, are found flattened triangular bodies, from less than an inch to an inch and a half in diameter, the nature of which

* See Fossils of the South Downs for figures of many species of the Cephalopoda of the Sussex Chalk.

is still somewhat problematical. A good figure is given by Mr. Parkinson of one species (*Org. Rem.* vol. iii. pl. xiii. figs. 9, 10, 12. See *Pict. Atlas*), with the name *Trigonellites latus*. These bodies frequently occur in pairs and in apposition, as in the specimen figured in *Lign.* 165. Their structure is cellular; one surface is slightly concave and striated, and the other covered with minute circular pores. Altogether their appearance is that of bodies enclosed in vascular integuments. It is supposed that they are the opercula of Ammonites. These fossils are commonly found in the last or body chamber of Ammonites, in the Oxford Clay, near Chippenham, the Coral Oolite of Malton, the Lias of Lyme Regis, and the lithographic limestone of Solenhofen. M. Ewald states that they may be found in the Chalk *Scaphites* by making a longitudinal section of the body chamber: but I have not succeeded in detecting them in the examples from the chalk-marl which I have broken up for that purpose. As these bodies (alluded to by authors as *Trigonellites, Aptychus, Munsteria*, &c.) will probably come under the observation of the collector, especially among the fossils of the Kimmeridge Clay, these remarks are introduced to suggest diligent research, in the hope that the origin of these fossils may at length be discovered.



LIGN. 165. APTYCHUS SUBLÆVIS. ½ *nat.*
Kimmeridge Clay, Hartwell, Bucks.
Fig. 1.—The convex surface.
1ª.—Magnified section of portion.
2.—The concave side.

GEOLOGICAL DISTRIBUTION OF FOSSIL CEPHALOPODA.—Even from this short review of the principal types of the fossil Cephalopoda, the great interest which attaches to the

study of this class of organic remains is strikingly demonstrated. Their geological distribution is alike replete with phenomena of an important character. In the Lower Palæozoic (Lower and Upper Silurian) strata, the chambered mollusks belong (with a very few doubtful exceptions) to the Nautilidæ, namely, Nautilus, Lituites, Cyrtoceras, Orthoceras, &c. The Devonian and Carboniferous systems contain Nautilus, Clymenia, Gyroceras, Cyrtoceras, and Orthoceras, together with a peculiar group of Ammonitidæ, the *Goniatites*. The Trias in general is extremely poor in Cephalopoda; the Permian group affording but two species of Nautilus, and the Muschelkalk two other species: but, in addition to these, the Muschelkalk contains Ceratites, which is a genus peculiar to the Triassic group, and chiefly abounds in the St. Cassian beds (in the Austrian Alps), where it is accompanied by Nautilus, Orthoceras, Ammonites, and Goniatites. In the Lias and Oolite Nautili abound, and we meet for the first time with Belemnites. The same families, viz. Nautilidæ, Ammonitidæ, and Belemnitidæ, prevail throughout the Cretaceous strata. The Tertiary formations contain a few Nautilidæ only; no vestiges of the Ammonitidæ and true Belemnitidæ, which, as we have seen, swarmed in the ancient seas, are perceptible, while in the existing oceans, the *Nautilus* and *Spirula* are the sole representatives of the numerous shell-bearing cephalopoda of the ancient geological eras. Thus, the Nautilidæ extend from the oldest to the newest fossiliferous strata, the genus being still in existence: the Ammonitidæ, on the other hand, though less ancient in origin, do not pass beyond the limits of the cretaceous epoch.

In the following tabular arrangement these facts are placed in a more distinct point of view:—

Tabular View of the Distribution of Cephalopoda through the Geological Epochs.

Existing Genera . . .	Argonauta. Octopus, &c.	Octopoda.	DIBRANCHIATA.
	Loligo, Cranchia, Sepiola, Onychoteuthis, &c. (*Teuthidæ*).	Decapoda.	DIBRANCHIATA.
	Sepia (*Sepiadæ*).	Decapoda.	DIBRANCHIATA.
	Spirula.	Decapoda.	DIBRANCHIATA.
	Nautilus (*Nautilidæ*).	TETRABRANCHIATA.	

Genera fossil in the Tertiary Formations	SEPIADÆ . . .	Sepia, Spirulirostra, Beloptera, and Belemnosis.
	NAUTILIDÆ . .	Nautilus and Aturia.
Cretaceous Deposits. .	BELEMNITIDÆ	Belemnites, Belemnitella, and Conoteuthis.
	NAUTILIDÆ . .	Nautilus.
	AMMONITIDÆ .	Ammonites, Crioceras, Scaphites, Ancyloceras, Toxoceras, Hamites, Ptychoceras, Helicoceras, Turrilites, Baculites.
Oolite and Lias . . .	SEPIADÆ . . .	Sepia.
	TEUTHIDÆ . .	Teudopsis, Beloteuthis, Geoteuthis, Leptoteuthis, Ommastrephes.
	BELEMNITIDÆ	Belemnites, Acanthoteuthis, and Belemnoteuthis.
	NAUTILIDÆ . .	Nautilus.
	AMMONITIDÆ .	Ammonites, Ancyloceras.
Trias	NAUTILIDÆ . .	Nautilus.
	AMMONITIDÆ*	Ammonites, Goniatites, and Ceratites.
Carboniferous System	NAUTILIDÆ . .	Nautilus, Gyroceras, Cyrtoceras, Gomphoceras, and Orthoceras, Actinoceras, &c.
	AMMONITIDÆ .	Goniatites.
Devonian System . . .	NAUTILIDÆ . .	Nautilus, Clymenia, Cyrtoceras, Phragmoceras, Gomphoceras, Orthoceras, Actinoceras, &c.
	AMMONITIDÆ .	Goniatites.
Upper and Lower Silurian Systems .	NAUTILIDÆ . .	Nautilus, Lituites, Gyroceras, Cyrtoceras, Phragmoceras, Gomphoceras, Oncoceras, Ascoceras, Orthoceras, Actinoceras, &c.

* The Ammonitidæ are from the St. Cassian beds only.

With regard to the zoological affinities between the living and extinct species of testaceous Cephalopoda, Dr. Buckland remarks, "that they are all connected by one plan of organization; each forming a link in the common chain which unites the existing species with those that prevailed among the earliest conditions of life upon our globe; and all attesting the identity of the design that has effected so many similar ends, through such a variety of instruments, the principle of whose construction is, in every species, fundamentally the same.

"Throughout the various living and extinct genera of these beings, the use of the air-chambers and siphuncle of their shells, to adjust the specific gravity of the animals in rising and sinking, appears to have been identical. The addition of a new transverse plate within the coiled shell added a new air-chamber, larger than the preceding one, to counterbalance the increase of weight that attended the growth of the shell and body of these animals." (*Bd.* p. 380.)

The occurrence of the Nautilus, and its congeners, among the earliest traces of the animal kingdom, and their continuance throughout the immense periods during which the family of Ammonitidæ was created, flourished, and became extinct, and the existence of species of the same genus at the present time, are facts too remarkable to have escaped the notice even of those who are not professed cultivators of geological science; and I am induced to quote the following beautiful lines, by Mrs. Howitt, to impress this interesting phenomenon more strongly on the mind of the youthful reader.*

* The poetess has, however, not been literally accurate regarding the Nautilus and its habits, nor as to the formation of stratified rocks, but has given a romantic rather than a scientifically correct view of this interesting Cephalopod, and of the disappearance of its congener. The young reader must, therefore, remember that the Nautilus sometimes *floats*, but *never sails;* and that the whole race

"TO THE NAUTILUS.

"Thou didst laugh at sun and breeze,
In the new created seas;
Thou wast with the reptile broods
In the old sea solitudes,
Sailing in the new-made light,
With the curl'd-up Ammonite.
Thou surviv'dst the awful shock,
Which turn'd the ocean bed to rock,
And changed its myriad living swarms,
To the marble's veinèd forms.

"Thou wast there, thy little boat,
Airy voyager! kept afloat,
O'er the waters wild and dismal,
O'er the yawning gulfs abysmal;
Amid wreck and overturning,
Rock-imbedding, heaving, burning,
Mid the tumult and the stir;
Thou, most ancient mariner,
In that pearly boat of thine,
Sail'dst upon the troubled brine.

ON THE COLLECTION OF BRITISH FOSSIL CEPHALOPODA.—In the Tertiary formations of England, the remains of but seven species of Nautilus (comprising Aturia) have been noticed; the large species (*N. imperialis*) is the most common. These are generally in a good state of preservation, and only require the careful removal of the surrounding clay or marl. When pyrites largely enters into the composition of the specimens, the investing matrix can seldom be effectually cleared off: if the outer surface, and general form, be not well displayed, breaking the specimen will often

of Ammonites *died out* in course of time, and were not annihilated by convulsive movements of earth and sea.

expose the inner cells, with the siphunculus, in a beautiful state. The *Nautilus imperialis* is occasionally imbedded in the septaria of the Isle of Sheppey, and of Bognor and Bracklesham, on the Sussex coast. Sections of such examples, in the vertical direction of the enclosed shell, afford, when polished, very brilliant and interesting fossils; the septa and the shelly tube of the siphunculus are often preserved.

The Cephalopods of the Cretaceous formation, with the exception of those in the argillaceous strata of the Galt, are generally destitute of their shells, and only occur in the state of casts; and the Chalk Nautili are liable to separate at the divisions of the septa, and an entire series of the casts of the chambers may sometimes be obtained, so as to display the entire form of the original shell. The Ammonites of the White Chalk, although mere casts, yet retain their configuration, the foliated margins of the septa dovetailing them together. I have already mentioned that search should be made along the back of these specimens for the siphuncle, the shelly tube of which is sometimes well defined. In the Chalk-marl the casts are sharper than in the White Chalk, and generally of a deep ochreous colour, with the lines of the sinuous septa clearly defined. The siphuncle is occasionally preserved in pyrites, in the Ammonites, Nautili, Turrilites, and Scaphites; and the outer lip or margin of the mouth, or aperture, of the latter, and of the Ammonites, is frequently replaced by the same mineral.

The Ammonites, Hamites, &c. of the Galt have their pearly coat remaining, but this investment is extremely delicate; and although when first removed from the marl it is beautifully iridescent, the vivid hues are very evanescent, and the shell becomes opaque and of a light fawn colour. Very commonly the shell flakes off, wholly or in part, leaving a cast of indurated pyritous marl. I have preserved specimens with the shell many years, by applying

a thin coat of mastic varnish with a soft camel-hair pencil, before the marl had become dry, and while the shells were entire. The Galt Ammonites, like the Nautili of the London Clay, are often invested with pyrites, and have the inner cells and siphuncle well preserved.

The argillaceous strata of the Oolite and Lias contain Ammonites, &c. in much the same state of mineralization as those of the Galt. The Kimmeridge Clay, in some localities, particularly around Aylesbury (and especially at Hartwell Park, the seat of Dr. Lee), abounds in Ammonites with the shell as perfect and beautiful as if just dredged up from the sea. But, like the fossils of the Galt, few of the specimens are durable; although in many examples the shell may be preserved by the application of mastic varnish. The most common Ammonite at Hartwell is *A. biplex* (*Sow. Min. Conch.*), which varies from three inches to one foot in diameter; the surface is covered by very strong ribs that encircle the whorls. The shell is thick, and composed of several laminæ.*

The sparry casts of the separate cells of Ammonites which occur in some of the calcareous beds of the Oolite, will not fail to be observed by the collector. It is convenient to preserve such specimens either on a tray or board, in which a groove is made for their reception, or in a mould of gutta percha.

In collecting *Belemnitidæ*, the caution already given, of examining the surrounding clay or marl, must not be disregarded; the student should remember, that traces of the soft parts of the animals, even of mere impressions of the body and

* According to the observations of my son, the outer layers, when highly magnified, present an appearance of opaque areolæ, with irregular radiating fibres; the inner laminæ are covered with minute pores, apparently the orifices of tubuli, some of which are arranged singly in crescents, and others are confluent, like short strands of beads. I mention the fact to direct attention to the microscopic examination of the structure of these splendid fossils.

head, with the tentacula and their acetabula, or little horny rings and hooks, are more important than the most splendid examples of the spathose durable osselet. The guards should be selected with especial reference to their containing the phragmocone (see *Lign.* 141, *fig.* 2), or chambered conical shell, in the alveolus or cavity of the upper and larger end. An apparently worthless fragment of a Belemnite will often be found to possess this part of the structure, as in the example figured, which, until fractured longitudinally, had been thrown by among useless duplicates. The search for the remains of the fossil naked Cephalopoda, as the Teuthidæ and Sepiadæ, and their ink-bags, must be made in a like cautious manner. In the Lias marls, the ink-bag and its duct is often found partially covered by a pellicle of nacre, without any trace of the other parts of the animal. A reference to Dr. Buckland's plates (*Bd.* pl. xxviii. xxix.) will familiarize the student with the appearance of these fossil remains.

A FEW BRITISH LOCALITIES OF FOSSIL CEPHALOPODA.

Abingdon, Berks. Ammonites, fine casts in spar and limestone; Middle Oolite.

Aylesbury, Bucks. Ammonites, several species; splendid examples of *A. biplex*, with the shell remaining, in the Kimmeridge Clay.

Aymestry. Upper Silurian; Gomphoceras, Orthoceras, &c.

Bath. Fine Ammonites in the Oolite.

Beachy Head. Along the shore, gigantic Ammonites in the Chalk, at low-water.

Benson, Oxfordshire. Fine Hamites, in Chalk-marl.

Blackdown, Devonshire. Beautiful siliceous casts of Ammonites; Green Sand.

Bognor, Sussex. Nautili, in the Tertiary Clays and sandy Limestones; also, along the neighbouring coast, in Septaria.

Bolland, Yorkshire. Mountain Limestone; Goniatites.

Boreham, near Warminster, Wilts. Nautili and Ammonites in Green Sand.

Swindon, Wilts. In the Portland-stone quarries, Ammonites, in abundance; principally casts of *A. biplex*, and *A. triplicatus*. In the Kimmeridge Clay in the vicinity, Ammonites with the shell preserved.

Tisbury, Wilts. In Portland-stone, fine Ammonites, often chalcedonic (see *Bd.* pl. xli.).

Trowbridge, Wilts. In Oxford Clay, Ammonites, Belemnites, &c. were obtained in great numbers during the railway cuttings.

Watchett, Somersetshire. *Ink-bags of Sepiadæ*, &c.; splendid Ammonites; Lias.

Whitby, Yorkshire. Ammonites, Belemnites, &c. in abundance; Nautili, &c.; Lias.

Yeovil, Somersetshire. Nautili and Ammonites; Inferior Oolite.

CHAPTER XIII.

FOSSIL ARTICULATA; COMPRISING THE ANNELIDES, CIRRIPEDES, CRUSTACEANS, AND INSECTS.

THE division of the Animal Kingdom termed *Articulata*, embraces, as the name implies, those animals which have a *jointed* body, generally possessing an external jointed skeleton, composed of segments more or less annular and distinct. It comprehends six classes; namely—

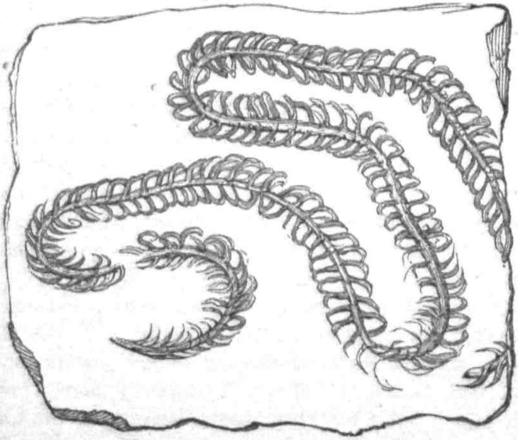
1. ANNELATA, or ANNELIDA; *i.e.* formed of rings; comprising the Red-blooded Worms.
2. MYRIAPODA; as the Centipede.
3. CIRRIPEDIA; *i.e.* having curled feet; as the *Balanus* and *Lepas* (Barnacle).
4. CRUSTACEA; as the Crab, Lobster, and Water Flea.
5. ARACHNIDA; Mites, Scorpions, and Spiders.
6. INSECTA, or Insects.

Of the first, third, fourth, and sixth of these classes, remains occur in the British strata, some being referable to existing, but the greater part to extinct species and genera. I propose to describe a few illustrative examples of the fossils belonging to each Class.

ANNELIDA.—This name is given to a class of *Articulata*, consisting of worms, whose bodies are formed of little rings, or annular segments, and which have red blood; as the Leech, Earth-worm, &c. Some are naked (the *Dorsibranchiata* and *Abranchiata*), and move with great celerity; as the *Gordius*, or Hair-worm, and the *Nereis*, so frequent on the sands of the sea-shore. Others have shelly coverings

(the *Tubicolæ*), as the *Serpula*, and are sedentary, or fixed to other bodies. The soft bodies of certain species are protected by a coat, or tube, formed by the agglutination of sand, or other foreign substances, as in the *Sabella* (*Lign.* 123, *fig.* 6, p. 385).

The fossil remains of the testaceous Annelides are very abundant in some deposits; and even the naked, flexible, soft-bodied forms have left proofs of their existence in some of the most ancient sedimentary rocks. Traces of nine species, belonging to five genera of these soft, naked Annelides, have been observed in the Silurian strata of Britain.



LIGN. 166. FOSSIL IMPRESSION OF NEREIS. *Silurian strata.*
(*Drawn by Miss Murray.*)
NEREITES CAMBRENSIS. (*Murch. Sil. Syst.*) *Llampeter.*

The first notice of these remarkable remains appeared in the invaluable work of Sir R. I. Murchison on the Silurian System.* The living species of NEREIS (*Dorsibranchiate*) are

* Murch. Sil. Syst. p. 699.

free, agile animals, having a distinct head, provided with either eyes or antennæ, or both; they are the most perfect in structure of all the Annelides. The fossil represented in *Lign.* 166 indicates that the body of the original was composed of about one hundred and twenty segments; the feet were half the length of a segment of the body; and the *cirri* of the feet were longer than such segment. A more slender species, (*Nereites Sedgwickii,*) the body consisting of a greater number of segments, is also figured and described by Sir R. I. Murchison. Other impressions in the same stone resemble those that would be produced by smooth Annelides (*Abranchiate*) related to the *Gordius*, or Hair-worm.*

Serpula.—The animals of this genus are sedentary or fixed, having calcareous tubes or shells, but to which they have no muscular attachment. They have plumose or arborescent gills affixed to the anterior part of the body. The shelly tubes of the *Serpulæ* are constantly seen on our coasts, encrusting stones, rocks, shells, sea-weeds, &c., and may be known by their contorted or twisted forms. There are a hundred and fifty British fossil Tubicolæ. A large species has been discovered in the Silurian rocks (*Murch. Sil. Syst.* pl. v. fig. 1); several occur in the Carboniferous, Oolitic, and Cretaceous, and many in the Tertiary strata. In the Upper Chalk, a smooth tortuous *Serpula* is not uncommon (*S. plexus, Min. Conch.* tab. 598); it occurs in masses several inches long. But I have not observed either in the Chalk, or in any other deposit, indications of banks of *Serpulidæ*, like those now in progress off the Bermudas, and which resemble coral-reefs in their solidity and extent.

Cirripedia.—These animals have a soft body, enveloped in a membrane, which in some genera is protected only by a horny sheath, but in general is enclosed in a shell com-

* Murch. Sil. Syst. p. 701, pl. xxvii.; and M'Coy, Cambridge Pal. Foss. p. 128, pl. 1. D.

posed of various calcareous plates.* They have six pairs of feet, terminating in long, slender, articulated tentacula, furnished with cilia, and coiled up like tendrils at the extremities near the mouth. The name of the class (*curled-feet*) has originated from the appearance presented by the curled tentacula when projecting from the oval aperture of the shell. The testaceous Cirripedes or *Barnacles* are divided into two groups; namely, the *sessile*, or those which in their adult state are fixed by the base to other bodies, (BALANIDÆ,) as the Acorn-shell, or *Balanus;* and the *pedunculated*, which have a process of attachment, peduncle or stem, (LEPADIDÆ,) as the Duck-barnacle, or *Lepas*. But the young animals of these genera have powerful locomotive organs, and are capable of swimming, by sudden jerks, like some of the crustaceans, to which class, especially in this stage of their existence, they closely approach. But after a short period of freedom, the young Cirripede fixes itself in some locality suitable to its economy, and rapidly undergoes the transformation which results in the sessile adult Barnacle or Lepas.†

BALANUS. *Lign.* 167, *fig.* 1.—The shell of this sessile Cirripede is of a conical shape and cellular structure. It consists of a thick plate at the base, or place of attachment; of a series of plates, united by sutures, arranged around the body of the animal, and called *parietal* valves; and of pieces termed *opercular* valves, by which the aperture is closed. The shell of the *Balanus*, so common on the rocks of our shores, and on every pile and pier within reach of the tide, is composed of six parietal, and four opercular valves. The

* Until within the last few years the valves of the *Cirripedes* have been generally figured and described in works on Conchology as being allied to the *Mollusca*.

† See Mr. C. Darwin's admirable Monograph on the Cirripedia, published by the Ray Society, 1851.

fossil *Balanus, Lign.* 167, *fig.* 1, is from the CRAG, a formation containing many shells of this genus: in this example, the six parietal plates of the conical shell only remain, but

LIGN. 167. FOSSIL BARNACLES AND PHOLADES.

Fig. 1.—BALANUS TESSELATUS. (*Sow. Min. Conch.*) *Crag. Suffolk.*
2.—LORICULA PULCHELLA. (*Mr. G. B. Sowerby, jun.*) *Chalk. Kent.*
a. The situation of the aperture of the shell.
3.—A valve (*Tergum*) of SCALPELLUM MAXIMUM. *Chalk. Lewes.*
4.—Another valve (*Carina*) of the same species.
5.—PHOLAS PRISCUS*; in wood. *Lower Green Sand. Sandgate.*
a. One of the shells seen in profile.
6.—Univalve Shells (*Neritæ*) in hollows formed by *Pholades*. (*Mr. Bensted.*) *Lower Green Sand. Maidstone.*
a. The *Nerites* lodged in the cavities.
b. Fragment of wood remaining attached.

in some specimens the opercular valves are also preserved. There are about twelve species of Balanus in the Crag; but none have been found either in the older Tertiary, or in the

* Figs. 5 and 6 are referred to and described at pages 409 and 410, vol. i.

secondary rocks of England. In the newer *Pliocene* deposits of the Sub-Apennines, and of North America, several species are common.

LEPADIDÆ.—The pedunculated Cirripedes, of which the common *Duck-barnacle* is a well-known example, have a strong, muscular, hollow stalk, or peduncle, which supports a multivalve shell, containing the body of the animal. In *Pollicipes* and *Scalpellum* there are small calcareous plates covering the junction of the body with the peduncle. Detached valves of several species of these two genera are met with in the Chalk, Galt, and Shanklin Sand, of Kent and Sussex; and three species have been found in the English Tertiary beds.* The valves of these fossil Cirripedes are most usually found in a disconnected state (*Lign.* 167, *figs.* 3 and 4); but the Tertiary *Scalpellum quadratum* is sometimes better preserved; and Mr. Morris has described a most beautiful group of *Pollicipes* (*P. concinnus*), attached to an Ammonite, from the Oxford Clay. Mr. Wetherell, of Highgate, has also discovered, in the Upper Chalk, near Rochester, an almost perfect Cirripede, named by Mr. G. B. Sowerby, jun., *Loricula pulchella* (*Lign.* 167, *fig.* 2), and lately more fully described in detail by Mr. Darwin.†

CRUSTACEA.—The animals whose fossil remains we have now to consider, are characterised by their crustaceous external integument or shell, which is disposed in segments, more or less distinct, the annular portions supporting articulated limbs or appendages. They are aquatic, free, locomotive beings, and possess distinct *branchiæ*, or organs fitted for aquatic respiration. The Crab and Lobster are examples of those tribes in which the external crust is calcareous, and "coloured by a pigmental substance, diffused

* See Mr. Darwin's Monograph of the Fossil *Lepadidæ*, Palæontographical Society, 1851.

† Monograph of the Fossil Lepadidæ, p. 81, pl. v.

more or less irregularly through it; and is formed upon and by a vascular organized integument, or *corium*, which is lined by the smooth serous membrane of the visceral cavities." (*Owen.*) The subdivisions of this class have relation to the forms, combinations, and proportions of the primary rings or segments of the external crust or integument, but it will not be requisite for our present purpose to enter upon this department of the subject. It may, however, be necessary to mention, that in the normal type of Crustaceans, the integument consists of twenty-one rings or segments, which form the three regions into which the body is divided; namely, the head or *cephalic*, the *thoracic*, and the *abdominal;* each of which is assumed to consist of seven rings, although some of these are generally anchylosed, and form but one segment; and even the three regions are occasionally more or less blended together. The *cephalic* portion of the crust contains the principal organs of sense, and the commencement of the digestive apparatus, and includes the masticatory appendages. The *thoracic* portion is formed of the rings to which the extremities serving for locomotion are attached; and, together with the cephalic, contains almost all the viscera. The consolidation of the rings or segments takes place most generally in the cephalic, and next in frequency in the thoracic; and but rarely occurs in the abdominal region. These animals possess organs of sight variously modified, and in some species highly complicated; some have smooth or simple eyes (*stemmata*), and others compound eyes, like those of insects, with distinct facets. In one grand division (called *Edriopthalmia*), the eyes are sessile and immoveable; in the other (*Podopthalmia*), they are supported upon moveable stems or peduncles. These few remarks on the organization of the recent crustaceans are required, to make our description of the fossil remains intelligible to the general reader. As the shell, or calcareous integument, even in those species in which it is

very dense and thick, is moulded upon the soft parts it envelopes, the experienced naturalist is able, from its configuration alone, to obtain certain conclusions as to the form, size, and position of the contained viscera; and, as these animals annually shed their solid case and acquire a new one, which is moulded on the soft parts, the form and relative situation of the internal organs must necessarily be faithfully represented by the external integument, even *when it has acquired its greatest degree of consolidation*; thus the regions of the stomach, heart, branchiæ or respiratory organs, &c. may be distinctly traced on the external shell. Hence the fossil carapaces may afford important data regarding the structure and economy of the extinct species. M. Desmarest* was the first naturalist who successfully applied this *phrenological method* to the investigation of the fossil crustaceans.

The fossil remains of Crustaceans consist of the calcareous covering or carapace, with the articulated extremities, and, rarely, the jaws and antennæ. For the most part, the specimens are mutilated, and present only portions of the carapace, abdominal segments, and detached claws; but in strata composed of very fine detritus, such as the cream-coloured limestones of Solenhofen and Pappenheim, examples often occur in the most beautiful state of preservation, appearing as if the animals had been carefully embalmed in a soft paste, that had quickly consolidated around them, and preserved them without mutilation or blemish. In some examples, even the colour of the original remains. The specimens found in hard limestones and coarse conglomerates are generally mutilated, and, as the under surface of the carapace, and the sternal plates to which the legs are attached, present more irregularity than the dorsal portion of the shell, they are firmly impacted in the stone, so as to

* Histoire Naturelle des Crustacés Fossiles; par MM. Alex. Brongniart et Desmarest. 1 tom. 4to. Paris, 1822.

render the development of some of the most important characters difficult, if not impossible. The antennæ and claws are often separated, or altogether wanting; the most common relics being the pincers and the carapace, or united cephalo-thoracic segments. The substance of the shell, which in the recent state consists of phosphate and carbonate of lime, with gelatine or cartilage, is commonly a friable carbonate of lime, tinged with oxide of iron. These remarks apply more particularly to the crabs, lobsters, shrimps, prawns, &c. Numerous species of the smaller crustaceans, as the *Cypris*, and the extinct family of *Trilobites*, occur in myriads, and, in some formations, are the principal constituent of deposits of great thickness and extent.

The remains of this class have been found throughout the vast series of the fossiliferous strata. Extinct forms appear in prodigious numbers in the most ancient formations, and are succeeded by genera which approach more nearly to the more highly organized crustaceans. The Crab and Lobster tribes are represented by certain species in the Lias, Oolite, and Chalk; while in many of the Tertiary strata the existing types prevail.

The London Clay, in the Isle of Sheppey, yields many beautiful examples of the higher order of crustaceans, as the Crab, Lobster, &c. In the Chalk these remains are more rare, but a few fine specimens have been obtained. On the Continent, certain localities are extremely rich in these remains. Upwards of sixty species were discovered by Count Munster in the Jura limestone, at Solenhofen; and the Muschelkalk of Germany has yielded several extinct genera. The beautiful state in which these fossils occur, is exemplified in the specimen from Solenhofen, figured in the frontispiece of this work; *Pl. I. fig.* 2.

Fossil Crabs.—Of the *brachyurous*, or short-tailed, crustaceans, of which the common Crab is an example, and of

the *Anomura* (abnormal-tailed), there are remains of several genera in the Tertiary deposits. The Isle of Sheppey is the most productive locality in England. The carapaces of several kinds occur in the septaria and nodules of indurated clay; the chelate hand-claws (*pincer-claws*) are often found detached, and sometimes in connexion with the shield. The most numerous specimens are referable to two species. One of them (*Cancer Leachii*) is from two to three inches wide, and has a convex shell, the surface of which is covered by minute punctations, with three tubercles on each anterior lateral margin.* The carapace of the other species is more distinctly lobed, and studded with aculeated or spiny tubercles; it is named *C. tuberculatus*.†

A species of Crab, characterised by its relatively large claws, is common in the soft Tertiary limesone of Malta; and examples, in a fine state of preservation, are often seen in cabinets; see *Wond.* p. 251.

I am not aware that vestiges of more than one genus of brachyurous crustaceans have been observed in the British Secondary formations; namely, the *Podopilumnus Fittoni* (M'Coy), from the Greensand of Lyme Regis: but several small species belonging to the anomurous group have been found in the Galt.

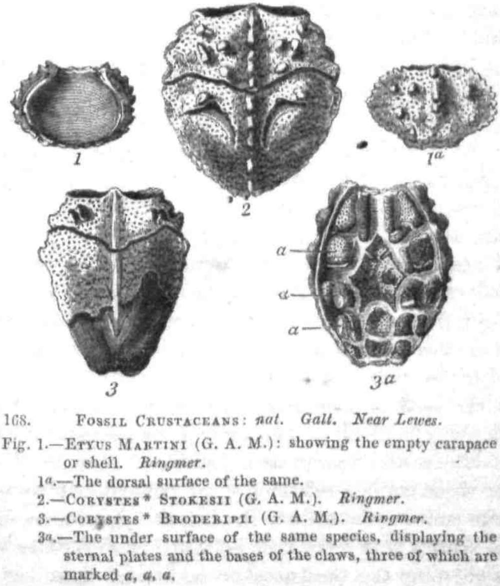
In the *Galt* at Ringmer, a village near Lewes, I discovered, many years since, four or five species of small crustaceans, which are figured and described, *Foss. South D.* pl. xxiv.; their natural relations were pointed out to me by the late eminent naturalist, Dr. Leach. Specimens of two of the species have since been collected at Folkstone, but as these are only the carapaces, no additional light has been thrown upon the structure of the originals.

The smallest species consists of the carapace or cephalo-

* Hist. Nat. Crust. Foss. pl. viii. figs. 5 and 6.

† König, Icones Foss. Sect. fig. 54. These two species are now referred to the genus *Zanthopsis*.

thoracic segments, united into a transversely obovate, obscurely trilobate shell, the surface of which is covered with minute irregular papillæ; with four tubercles on each lateral portion, and an irregularly tuberculated dorsal ridge (see *Lign.* 168, fig. 1, 1a.); it probably belongs to the genus ETYUS; and I have named it *Etyus Martini*, in honour of my friend, P. J. MARTIN, Esq., author of several excellent Memoirs on the Geology of Western Sussex.



LIGN. 168. FOSSIL CRUSTACEANS: *nat. Gall. Near Lewes.*

Fig. 1.—ETYUS MARTINI (G. A. M.): showing the empty carapace or shell. *Ringmer.*

1a.—The dorsal surface of the same.

2.—CORYSTES* STOKESII (G. A. M.). *Ringmer.*

3.—CORYSTES* BRODERIPII (G. A. M.). *Ringmer.*

3a.—The under surface of the same species, displaying the sternal plates and the bases of the claws, three of which are marked *a, a, a.*

There are two species that appear to have some relations with *Corystes*, a genus which includes several recent crustaceans that inhabit our shores, and are characterised by their

* These two crustaceans are included in the fossil genus NOTOPOCORYSTES, established by Professor M'Coy, 1849.

elongated oval shell and four antennæ, the external pair being long, setaceous, and furnished with two rows of cilia. The tail is folded under the body when the animal is in repose. They have ten legs, the anterior pair *chelate* (*with pincers*), the others terminating in an acute elongated nail or claw. The fossils consist of the carapace, and one example possesses the inferior or thoracic plates and the remains of the bases of some of the legs (see *Lign.* 168, fig. 3ª).

NOTOPOCORYSTES STOKESII. *Lign.* 168, *fig.* 2.—The carapace is relatively wider than in most species of this genus: is has a strong dorsal ridge of irregular oblong tubercles: the union of the cephalic and thoracic segments is marked by a transverse undulated groove; there are three or four tubercles on the surface of each lateral portion of the former, and one on each of the latter. The whole surface is finely granulated. The openings left by the attachment of the peduncles of the eye remain.

NOTOPOCORYSTES BRODERIPII. *Lign.* 168, *fig.* 3.—This species, like the former, has a transverse undulated furrow, indicating the union of the cephalic with the thoracic segments; the dorsal ridge is smooth, and there are two tubercles on each lateral cephalic portion of the shield. The carapace is longitudinally ovate, much depressed, with three sharp points directed forwards on each margin of the anterior part: the whole surface is finely granulated. In the specimen fig. 3ª the sternal plates, with portions of the first joints of the claws, remain; one example (figured *Geol. S.E.* p. 169) possessed six or seven arcuate abdominal segments, which were turned under the body.*

The carapace or shell of the other crustacean observed in the Sussex Galt (*Notopocorystes Bechei*) is of an orbicular

* I have described these small crustaceans somewhat minutely, and have given them specific names, in the hope of directing the attention of collectors to these highly interesting relics, and leading to the discovery of more illustrative examples. See Foss. South D. pp. 96, 97.

inflated form (see *Geol. S. E.* p. 169, fig. 3), and ornamented with twelve or thirteen aculeated tubercles; its margin is dentated.

In the friable arenaceous limestone of the Cretaceous formation at St. Peter's Mountain, near Maestricht, the cheliferous claws of a small kind of crustacean (*Mesostylus Faujasii*, *Wond.* p. 338), are frequently discovered (and occasionally in the Chalk of Kent and Sussex), but with no vestige of the carapace or shell. This curious fact is explained by the analogy existing between the fossil claws and those of the *Pagurus*, or Hermit-crab, whose body is only covered by a delicate membrane, the claws alone having a calcareous covering; hence the latter might be preserved in a fossil state, while no traces of the soft parts remained. In the fossil, as in the recent claws, the right arm is the strongest. There is no doubt that the crustaceans to which the fossil claws belonged possessed the same modification of structure as the recent (anomurous) Hermit-crab, and must have sought shelter in the shells of the mollusks with which their durable remains are associated.

Fossil Lobsters.—The *macrurous*, or long-tailed, crustaceans, as the *Lobster*, are distinguished from those of the former divisions by the prolonged abdomen (or tail, as it is commonly termed), which forms a powerful instrument of locomotion, and enables the animal to dart backwards through the water with great rapidity; and this is furnished with an appendage or tail, which none of the ambulatory crustaceans possess.

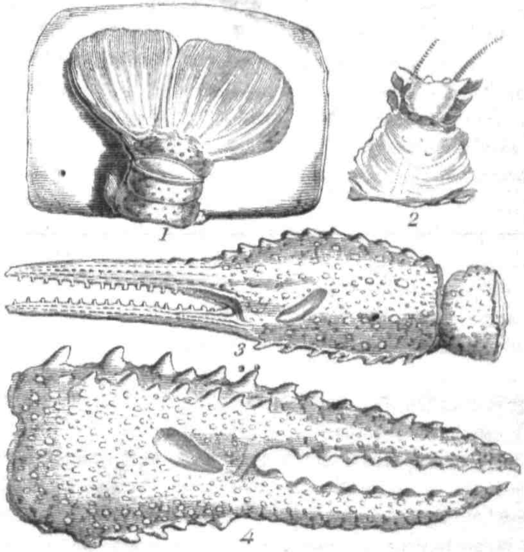
Of the fresh-water species, the Cray-fish (*Astacus fluviatilis*), and of the marine, the Lobster (*Astacus marinus*), are illustrative examples. The remains of three macrurous species occur in the London Clay of the Isle of Sheppey, associated with congenerous crustaceans; and the segments of the tails (*post-abdomen*) are often well preserved.

The Chalk contains a few species of the *Macrura*, which were first discovered in the quarries near Lewes, and are figured in *Foss. South D.* tab. xxx. xxxi.; they are among the most rare and delicate of the fossils of the Cretaceous strata. These remains consist of the carapace and claws, and rarely of the tail and antennæ, and are composed of a friable earthy crust, which, when first discovered, is of a dark chocolate colour, but quickly changes to a pale fawn, or reddish brown, by exposure to the air. In the specimens obtained by breaking the stone, the crustaceous covering remains attached by its rough external surface to one portion of chalk, and on the corresponding piece are sharp casts of the carapace and claws, having a glossy surface covered with minute papillæ formed by the bases of tubercles or spines. Four species have been observed.

Enoploclytia Leachii. *Lign.* 169, *figs.* 1, 2, 3.—This is a long delicate crustacean, having a pair of equal, slender, anterior chelate claws, the fingers of which are long, attenuated, and armed with a row of obtuse cylindrical spines. The surface of the hand-claws is muricated, or covered with short erect aculeated tubercles. The pincers in the specimen figured *Lign.* 169, *fig.* 3, are shorter than in most examples. The carapace is elongated and subcylindrical, with a dorsal ridge and two lateral furrows, indicating the normal division of the cephalic and thoracic segments of the shield; the antennæ are long, filiform, and setaceous (*bristly*), and are placed on squamous peduncles (see *Lign.* 169, *fig.* 2).

There appear to have been five legs on each side; the anterior or chelate pair are the most usual relics of this animal; of the other claws and the branchiæ, but obscure indications have been obtained. The abdominal segments are arcuate, and six or seven in number; their surface is granulated; the appendage, or tail, is foliaceous and mar-

ginate, with a few longitudinal ridges (see *Lign.* 169, *fig.* 1).* The claws of these crustaceans may be easily recognised by



LIGN. 169. FOSSIL CRUSTACEANS: *nat. Chalk. Lewes.*

Fig. 1.—Abdominal appendage, or tail, of ASTACUS† LEACHII (G.A.M.), with three abdominal segments.

2.—Part of the head of *Astacus Leachii*, with remains of the squamous peduncles of the antennæ, and of the long setaceous antennæ.

3.—Chelate claw, with part of the *carpus*, or wrist, of *Astacus Leachii*.

4. Chelate claw of ASTACUS† SUSSEXIENSIS (G. A. M.).

their general aspect, and the length and straightness of the fingers or pincers. In most examples traces remain of the

* See Foss. South D. p. 221, *et seq.* for further details.

† These fossil Lobsters are now to be referred to Prof. M'Coy's genus ENOPLOCLYTIA.

tendinous expansion of the muscles of the moveable claw (see *Lign.* 169, *fig.* 3).

ENOPLOCLYTIA SUSSEXIENSIS. *Lign.* 169, *fig.* 4.—The claws of this species are readily distinguished from the former by their broader and stronger proportions, and spinous character; the pincers are strong and tuberculated, and the moveable finger is more curved and shorter than its opponent. The entire crust of this lobster is muricated, or beset with spines and sharp tubercles.*

Claws of other *Astacidæ* have been found in the Chalk of Sussex and Kent; one species in particular is distinguished from those previously described by its short curved pincers, and granulated surface;† and remains of other species of *Enoploclytia*, from near Cambridge and Maidstone, are described by Prof. M'Coy.

The "Lobster-clays" in the Lower Greensand, or Neocomian, beds at Atherfield afford numerous fine specimens of a small long-clawed crustacean, allied to *Astacus;* a fine specimen is figured in the *Geology of the Isle of Wight*, title-page vignette, and see page 232. One or more species, apparently distinct from those of Atherfield, have been dis-

* Foss. South D. tab. xxx. fig. 3. In the beautiful work of the late Mr. Dixon, on the Fossils of Sussex, there are figures of very fine specimens of these two species of Enoploclytia (plate xxxviii*.), with detailed descriptions by Prof. Bell (p. 344); but unfortunately, from inadvertence, no reference is made to my former drawings and descriptions of these fossil Lobsters of the Chalk, and new names are given by the Professor; *E. Leachii* appearing as "Palæastacus macrodactylus," and *E. Sussexiensis* as "P. Dixoni." I need scarcely remind my readers that according to the established rules of Nomenclature the *earlier specific names* must be preserved; and that, Prof. M'Coy having already indicated the distinction of these fossils from the recent *Astacus* by providing an appropriate generic appellation, these new names are altogether inadmissable.

† This species may be named *Astacus cretosus*, to indicate its geological habitat.

covered by Mr. Beckles in beds of clay that appear to occupy the line of junction between the Wealden and Greensand, on the Sussex coast, between Pevensey and Bexhill.

Imperfect claws of *Astacidæ* have also been found at other places in the Shanklin Sand; and I have collected from the Galt at Ringmer, the abdominal segments of a small species, resembling *Meyeria ornata*, *Lign.* 170.

The carapaces of two or three small *Astacidæ*, sometimes with the abdominal segments attached, as in the beautiful

LIGN. 170. FOSSIL CRUSTACEAN. *Speeton Clay. Yorkshire.* MEYERIA ORNATA: *nat.* (*Phillips and M'Coy.*)

ossil figured in *Lign.* 170, are found in the Speeton Clay, near Scarborough. In this example the post-abdomen and its appendages are entire, and traces remain of the antennæ and some of the feet. These specimens are commonly imbedded in masses of indurated clay, as the fern-leaves in the Carboniferous ironstone, and are discovered by splitting the nodules through their longest diameter. The carapace of another small species (*Glyphea rostrata*)* occurs in the Oolite of Scarborough. My friend, the Rev. J. B. Reade, has also discovered an example of this species in that rich

* This is the *Astacus rostratus* of Prof. Phillips's Geol. York. vol. i. tab. 4, fig. 20.

repository of organic remains, the Kimmeridge Clay, at Hartwell, Bucks.

A remarkable macrurous crustacean (*Eryon Cuvieri*) is found in the Jurassic limestone of Solenhofen. Perfect specimens of this species are occasionally seen in collections; it is distinguished by its very large, flat, oval shell, with the front lateral margins strongly dentated, and by its short setaceous antennæ; the front claws are as long as the body, and armed with pincers; the post-abdomen consists of six segments, terminating in a caudal appendage or tail.

In the United States several fossil crustaceans have been noticed in the Cretaceous strata of New Jersey; some of which are said to be related to *Pagurus*, and others to *Astacus*.

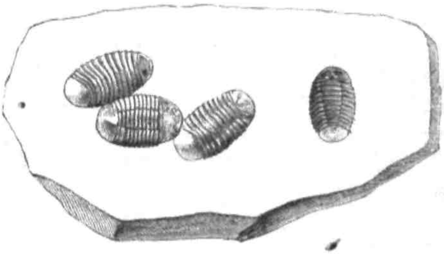
Fossil Prawns and Shrimps, of exquisite beauty, are found in the lithographic limestone of Pappenheim: a specimen from that locality (*Palæmon spinipes*) is figured *Wond.* p. 513: see also Frontispiece of this work.

A large crustacean of the Shrimp family has been discovered by the Earl of Enniskillen in the Lias of Lyme Regis.* Other specimens also of Macrura, more or less perfect, have been obtained from the same rich mine of organic remains: especially some in which the *branchiæ*, or respiratory organs, remain; and a portion of the post-abdomen, or tail, of a Cray-fish, as large as the common species.

ISOPODOUS CRUSTACEANS. *Lign.* 171.—ISOPODA (*equal-feet*) is the term applied to an order of crustaceans in which the body is composed of a distinct head, and seven rings, each having a pair of equal feet; the common *Oniscus*, or wood-louse, is a familiar example of a terrestrial *Isopod*. This order includes many genera and species, some of which nearly

* This beautiful fossil is figured and described by Mr. Broderip, Geol. Trans. second series, vol. v. pl. xii. under the name of *Coleia antiqua*.

approach the extinct family of crustaceans (Trilobites) whose remains abound in the palæozoic strata; and the parasitical Isopod, *Bopyrus*, that infests the common Prawn, is closely related to certain genera of Trilobites, hereafter described.



LIGN. 171. ARCHÆONISCUS BRODIEI. *Purbeck limestone. Vale of Wardour.*
(*Drawn by S. P. Woodward, Esq.*)
Impressions of the upper and under surfaces.

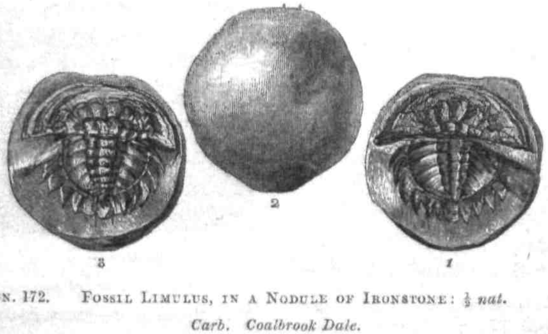
One species of fossil *Isopod* has been found in green fissile marl, at Montmartre; and another in fine-grained limestone, probably, from Pappenheim.* No fossil remains of this order had been noticed in the British strata, until the discovery of the *Archæoniscus* in the Purbeck strata by the Rev. P. B. Brodie. The quarry in which these relics were found is situated at Dallards, near the village of Dinton, about twelve miles west of Salisbury. They are principally distributed in a bed of light-brown and grey limestone, in the lower part of which are numerous fresh-water bivalves (*cyclades*), and a few small oysters. These Isopods often occur in clusters (see *Lign.* 171); the lenses of the compound eyes are sometimes detectable in the limestone, and, rarely, attached to the head; traces of legs have been observed, but no antennæ. In the same stratum the *elytron* (sheath, or wing-case) of a coleopterous insect was dis-

* Nat. Hist. Crust. Foss. p. 138.

covered. Mr. Brodie has obtained specimens an inch and a half in length, and an inch broad. These fossils appear to have been deposited tranquilly at the bottom of the water which they inhabited, since they are usually found imbedded with their legs downwards, and generally well preserved.*

The *Archæonisci* also occur in the Purbeck insectiferous limestone of Durlstone Bay, near Swanage, and have been discovered in strata of a similar character at the Ridgway railway-cutting, between Dorchester and Weymouth, by the Rev. Osmond Fisher, of Dorchester.

ENTOMOSTRACA.—The Crustaceans that we have above noticed belong to the Sub-class MALACOSTRACA; and we have now to describe some fossil genera belonging to various divisions of the Entomostracous Crustaceans.



LIGN. 172. FOSSIL LIMULUS, IN A NODULE OF IRONSTONE: ½ *nat.*
Carb. Coalbrook Dale.

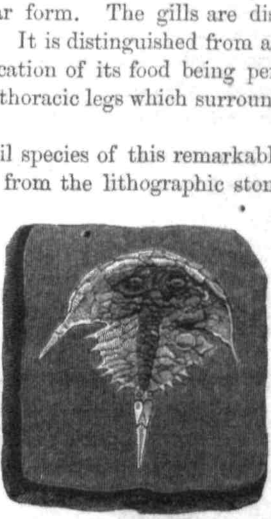
Fig. 1.—LIMULUS ROTUNDATUS, the imprint of fig. 3.
2.—The nodule before it was broken.
3.—LIMULUS ROTUNDATUS, (the corresponding portion of the nodule, fig. 1,) showing the entire form of the carapace.

The LIMULUS (MOLUCCA OR KING CRAB) is a genus belonging to that Division of the Entomostraca termed PŒCILOPODA, and is abundant in the seas of India and America. The

* See Brodie's Fossil Insects, pp. 3 and 10.

carapace is crustaceous and of a semilunar form, the head and thorax are blended together, and the superior abdominal shield, which is composed of confluent segments, appears like one piece, and has an indistinct trilobed character; the last segment is prolonged into a three-edged, sharp, styliform weapon. The Limulus has two reniform, compound eyes, composed of facets of a peculiar form. The gills are disposed on lamelliform processes. It is distinguished from all other crustaceans by the mastication of its food being performed by the first joint of the thoracic legs which surround the mouth, instead of by jaws.

Very fine examples of a fossil species of this remarkable genus are occasionally obtained from the lithographic stone of Solenhofen.* In England three small species have been discovered in nodules of iron-stone and indurated clay, in the Carboniferous strata of Coalbrook Dale, by Mr. Prestwich.† In one example (*L. Anthrax*‡) two of the legs are seen extending from under the body; in another species the sharp, pointed process of the tail is well developed (*Buckl.* p. 396, and tab. xlvi″.; see also *Lign.* 173). The specimen figured *Lign.* 172 is one of several examples which I obtained by breaking up nodules from that celebrated locality. *Fig.* 2 represents the nodule unbroken, and without any



LIGN. 173.

LIMULUS TRILOBITOIDES.

Coal Measures. Coalbrook Dale.

* Hist. Crust. Foss. pl. xi. fig. 6.

† See Mr. Prestwich's Memoir on the Geology of Coalbrook Dale, Trans. Geol. Soc. second series, vol. v. part 3.

‡ Trans. Geol. Soc. second series, vol. v. pl. xli. figs. 1—4.

indication of its contents; by a well-directed blow it was separated into two equal portions, *figs.* 1 and 3, in which the carapace of the crustacean, and its marginal appendages, are well displayed. The rounded form of the carapace, and the membrane which appears to connect the spines, separate this species from all others.

The EURYPTERUS and PTERYGOTUS are palæozoic crustaceans, of large size. They are regarded by Prof. M'Coy and Mr. Salter as belonging to the *Pœcilopoda*, and as differing from the Limulus chiefly in having the segments of the abdomen freely articulating with each other.* The *Eurypterus* was first described by Mr. Dekay, in the United States, probably from the Carboniferous system. The head is round, the thoracic and cephalic portions of the carapace being blended together, and the abdominal region is formed of eleven segments, with a caudal appendage. It has two depressed, lunated eyes, remote from each other, and eight feet, the anterior pairs furnished with *branchiæ*, and the hindmost pair relatively larger than in any other crustacean. Two American species are described; the one is five, and the other about four inches long.† In the Carboniferous strata at Burdie-house, near Edinburgh, and of Kirton, near Glasgow, a large species of this curious genius has been found by Dr. Hibbert and Dr. Scouler; the length of some specimens being estimated at from twelve to eighteen inches.‡

Other species of *Eurypterus* have been noticed in the Upper Silurian rocks of Kendal, Westmoreland,§ and of Kington, Radnorshire; and in the Devonian of Russia.

* See Salter on Pterygotus, Quart. Journ. Geol. Soc. vol. viii. p. 387.

† Dr. Harlan, in Trans. Geol. Soc. Pennsylvania, vol. i. p. 96.

‡ See the elegant Memoir on the Fresh-water Limestone of Burdie-house, near Edinburgh, by Samuel Hibbert, M.D. F.R.S.E.

§ Pal. Foss. Cambridge, Appendix.

PTERYGOTUS.—In the Old Red sandstone of Forfarshire, and other parts of Scotland, the remains of this remarkable crustacean have been long known to the quarrymen by the name of "*petrified Seraphims*;" from an imaginary resemblance of the expanded post-abdomen to the usual representations of those ideal beings! This genus is characterised by the angular carapace, which forms a lozenge-shaped shield; and the appendage of the post-abdomen, which, instead of being divided into segments, as in most animals of this class, is a continuous flap. The eye-pits on the carapace are like those of Eurypterus, but are very large. The claws resemble those of the common lobster. The external crustaceous covering is ornamented with circular and elliptical markings, producing an imbricated or scaly appearance, the imprints of which gave rise to the enigmatical "Seraphims" of the Forfarshire sandstone. Some specimens indicate a total length of four feet!*

Besides this Devonian species (*P. anglicus*), there is also a Silurian species (*P. problematicus*), from Herefordshire.†

Several fossil genera of the Entomostracous Crustaceans belong to the *Phyllopoda* (*leaf-feet*), which constitute a subdivision of the BRANCHIOPODA (*gill-feet*). Of these perhaps the most remarkable is the DITHYROCARIS, first discovered by Dr. Scouler in the Carboniferous shale near Paisley. This genus is allied to the recent *Apus*, and, like it, has a broad, flat, thin carapace, easily divisible down the middle of the back, and a lengthened tail or post-abdomen, with a trifid termination. Six species have been found in the Carboniferous deposits of the British Isles.

CERATIOCARIS and HYMENOCARIS, which are related to the

* The Old Red Sandstone, or New Walks in an Old Field, by Hugh Miller, p. 147. There are specimens in the British Museum from the quarries of Carmylie.

† See Quart. Journ. Geol. Soc. vol. viii. p. 386.

recent *Nebalia*, are also of the Phyllopod group, and may be said to resemble a shrimp-like animal partly enclosed in a bivalve carapace, while its tail is exposed, and either protruded, or turned beneath the body. Of the first-mentioned genus there are three Upper Silurian species; and of *Hymenocaris* Mr. Salter has described a single species (*H. vermicanda*) from the Lower Silurian (Cambrian) of North Wales.

The *Limnadiadæ*,—another Phyllopodous family, of which the recent *Limnadia* is the type,—are well represented in the older rocks. These Crustaceans are also bivalved, but the body is wholly enclosed. They are of small size. ESTHERIA, a genus closely related to Limnadia, occurs plentifully in the Wealden of Sussex and Germany, and in the Lias of Westbury. Mr. Bean also has noticed a species (*E. concentrica*) in the Oolite shell of Gristhorpe Bay; and the *E. minuta** is characteristic of the Keuper division of the Trias in England and Europe.

LEPERDITIA and BEYRICHIA are other fossil genera belonging to the *Limnadiadæ*. These little crustaceans were gregarious in their habit, and, like Estheria, occur locally in great profusion. They are characteristic of the Silurian deposits; the former being an abundant Upper Silurian fossil in Europe and North America; and the latter,—a very minute form,—both in the Upper and Lower Silurian.

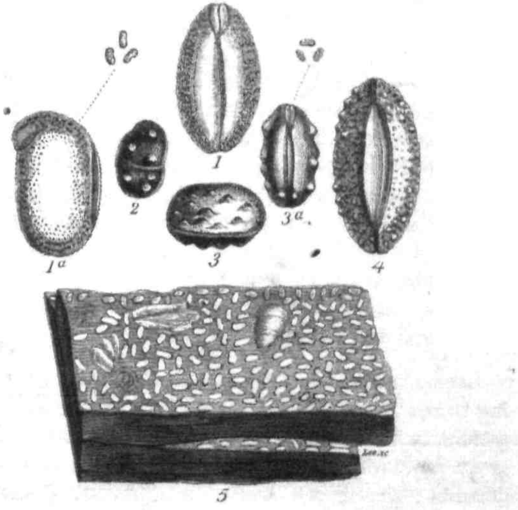
The next group of Entomostraca that we have to notice belongs to the LOPHYROPODA (*feet crested with bristles*), namely, the OSTRACODA (*shelled*). The recent genera, *Cypris*, *Cythere*, and *Cypridina*,† are types of the three families of

* This was formerly described as a *Posidonomya*.

† The student should consult Dr. Baird's elegant and elaborate work on the Natural History of the British Entomostraca (published by the Ray Society), for information on the characters and habits of these interesting little crustaceans and their numerous allies.

this group, and are the existing representatives of numerous closely related forms that occur in a fossil state.

Cypris. *Lign.* 174.—The animals of this genus belong to those Crustaceans in which the covering of the body is not



Lign. 174. Fossil Cyprides. *Wealden. Sussex and Isle of Wight.*

Fig. 1.—Cypris Valdensis: *magn.*; showing the ventral aspect of the united valves. *Cooksbridge.*

1a.—Side view of the same, *magn.* The three small figures are of the *nat. size.*

2.—Cypris Fittoni, *magn.* *Langton Green.*

3.—Cypris tuberculata, *magn.* *Langton Green.*

3a.—View of the same, showing the lower edges of the valves united: the three small figures, *nat.*

4.—Cypris granulosa, *magn.*; view showing the hinge-line.

5.—A piece of Weald Clay, with Cyprides and Shells; *nat.*

divided into transverse segments, but consists of a large dorsal shield, having the form of a bivalve shell. They are often very minute, and numerous kinds swarm in our lakes and pools.

The species of an allied genus, named *Cythere*, the shells of which cannot always with certainty be distinguished in a fossil state from those of *Cypris*, inhabit salt or brackish waters. As the living *Cyprides* are interesting objects for microscopic examination, they are commonly shown in the exhibitions of the hydro-oxygen microscope, and their appearance is therefore well known. Two recent species are figured in *Ly.* p. 183. These animals have the body enclosed in a bivalve, horny case, the two pieces being united by a hinge-line. They have four feet, and two pairs of antennæ, with a pencil of cilia at the extremities; and one compound eye. They swim with rapidity, by means of their ciliated antennæ, and crawl about actively on the water-weeds and other subaqueous surfaces. Like the other crustaceans, they frequently moult or cast their cases, and the surface of the mud spread over the bottoms of still lakes is often covered with their exuviæ. The largest living Cypris (*C. clavata*) does not exceed one-eighth of an inch in length. The fossil cases or shells of Cyprides are found in considerable variety and in prodigious numbers in certain Tertiary and Secondary strata, which appear to have been deposited by fresh-water; as, for example, in the lacustrine marls of Auvergne (*Ly.* p. 183), and the fluviatile clays and limestones of the south-east of England. They have not been observed in any decidedly marine beds; but Mr. Lonsdale discovered in the Chalk, by means of the microscope, cases of crustaceans, that belong to the genus *Cythere* (*Ly.* p. 26, figs. 21—24), the recent species of which inhabit the sea. One or more species of Cypris have been observed in the older British Tertiaries,—by Sir C. Lyell, in Hordwell Cliff (*Geol. Trans.* 2d ser. vol. iii. p. 288), and by Mr. Prestwich at Hempstead Cliff (*Brit. Assoc.* 1846); but in the Pleistocene deposits the *Cypris* and its congeners abound, and of these Mr. R. Jones has enumerated nine species (*Annals Nat. Hist.* 2d ser. vol. iii.). In many districts on the Continent, the

Eocene marls and clays abound in these remains. Some of the fresh-water Tertiary strata of France contain myriads of a Cypris (named *C. faba*, from its bean-like form) which was formerly supposed, but erroneously, to be identical with a species found in the Wealden. The laminated marls of Auvergne contain, between every layer, countless myriads of the shells of Cyprides, through a depth of several hundred feet; although each lamina of marl scarcely exceeds the thickness of paper. Near Clermont, the green *cypridiferous* marls approach to within a few yards of the granite which forms the borders of that ancient basin (*Ly.* p. 184). In the eastern portion of the basaltic districts of India, Mr. Malcolmson has discovered two species of Cypris, associated with fresh-water univalves and bivalves.* In England the principal deposits of the Cyprides, are the clays and limestones of the Wealden and the Isle of Purbeck,† to the composition of which the relics of these minute beings have largely contributed. Entire layers of their cases are found in the laminated clays and marls on the southern shores of the Isle of Wight, at Atherfield and Sandown Bay, where some of the Wealden beds emerge from beneath the lower division of the Shanklin sand. Upon splitting the clay in the direction of the laminæ, the exposed surfaces are found to be covered with these minute bodies; as in the specimen, *Lign.* 174, fig. 5.

The appearance of four characteristic Wealden Cyprides, of their natural size and magnified, is shown in *Lign.* 174. The one named *C. Valdensis*, or Wealden Cypris, by Dr. Fitton and Mr. Sowerby (fig. 1), is the most frequent, and occurs in numerous localities in Kent and Sussex. A Cypris having the case studded with relatively large tubercles

* Geol. Trans. 2d ser. vol. v. pl. xlvii.

† On account of the distinctive characters of their carapace-valves, M. Bosquet has suggested the appellation *Cypridea* as a generic name for the Cyprididæ of the Wealden and Purbeck beds.

(fig. 3), is found in many of the finer sandstones of Tilgate Forest; another, with the shell tuberculated, but divided by a transverse ridge (fig. 2), indicating a rudimentary condition of the segments which characterise the class, is certainly distinct from the former, and can have no name more appropriate than that of *C. Fittoni*. The other beautiful species (*C. granulosa*, fig. 4) has the surface of the case covered with granules. One more species has been observed in the Weald clay, at Sandown Bay and Atherfield (by Mr. Lonsdale); it is distinguished by a short conical spine on each valve, and is therefore named *C. spinigera*. In the Weald clay at Resting-oak-hill, near Cooksbridge (*Geol. S. E.* p. 187), *C. Valdensis* is so abundant, that every thin flake is covered with its white calcareous shells; and upon breaking the nodules and septaria of reddish-brown ironstone which occur in that locality, myriads of beautiful sharp casts of the cases are observable in almost every fragment. They are associated with fresh-water bivalves and univalves (*Cyclas* and *Paludina*), and minute scales of fishes. The sandstone at Langton Green, near Tunbridge Wells, which contains casts and impressions of several species of fresh-water shells, abounds in *Cyprides*; and the layers of argillaceous ironstone, interstratified with the sandstone in one of the quarries, are particularly rich in these remains. The surface of a recently broken slab is often covered by minute, polished, oblong, convex bodies, which are the casts of cypridean carapaces.

The Sussex marble is largely composed of the remains of these minute crustaceans. Upon examining thin polished slices of this limestone under the microscope, the cavities and interstices of the shells are found to be filled with the shields of Cyprides, entire or in fragments; and some specimens of the Purbeck marble equally abound in these remains. The Purbeck marls, as well as the limestones, often abound with Cyprides. According to Prof. E. Forbes, these

belong to several species, all more or less distinct from those of the Wealden (*Brit. Association*, 1850). The Cyprides of the Wealden of Germany have been figured and described by Dr. Dunker; and several of the British forms are found there.

As the recent species inhabit still lakes, or gently running streams, and not the turbulent waters of estuaries, we cannot doubt that the strata in which these animals so largely predominate were deposited in lakes or bays, communicating with the river which transported to their present situation the bones and other remains of the colossal reptiles of the Wealden. And the beds of fresh-water snails, with scarcely any intermixture of other organic remains but the Cyprides, which are spread over extensive areas in the Wealden and Purbeck districts, appear to afford corroborative proof of this inference.

Four species of minute, bivalved Entomostraca from the Carboniferous deposits have been referred to *Cypris*: viz. *C. arcuata*, Bean, from the Coal-shale at Newcastle; *C. inflata*, Murchison, Coal-measures, near Shrewsbury; *C. Scoto-Burdigalensis*, Hibbert, Coal-measures at Burdie-house, and Coal-shale at Derry; and *C. subrecta*, Portlock, also from Derry, Tyrone.

CYTHERE.*—This animal differs but little from Cypris except in having an additional pair of feet. In the Subgenus CYTHEREIS the valves are thick, oblong, and strongly hinged; thus differing from the thin and more or less oval valves of the true Cythere and of Cypris. Several species of *Cythere* and its subgenera occur in the Tertiary, Cretaceous, Oolitic, Liassic, Permian, and Carboniferous deposits.†

* For description and illustration of this genus, see Baird's British Entomostraca, p. 163, &c.

† Consult M. Bosquet's Memoir on the Tertiary Entomostraca of Belgium and France; Mr. T. R. Jones's Monograph of the Cretaceous Entomostraca (Palæontographical Society), and of the Permian Entomostraca, in Prof. King's Monograph of the Permian Fossils

Three species of Entomostraca, very closely related to CYPRIDINA,* from the Carboniferous rocks of Belgium, have been figured and described by M. De Koninck; one species from the Carboniferous rocks of Ireland, by Prof. M'Coy;† and two species from the Cretaceous limestone of Maestricht,‡ by M. Bosquet. The genera *Cyprella* and *Cypridella* have been established by M. De Koninck for the reception of some allied forms found in the Carboniferous strata of Belgium; and *Entomoconchus* (M'Coy) and *Daphnoidia* (Hibbert) are allied British Carboniferous forms.

TRILOBITES.—Among the numerous petrifactions which are found in the limestones in the neighbourhood of Dudley, in Staffordshire, there are certain fossil bodies which, from their extraordinary form and appearance, have for more than a hundred and fifty years been objects of great interest to the naturalist, and of wonder to the general observer, and have long been provincially termed *Dudley insects*, or *locusts*.§ By the earlier naturalists these fossils were referred to fishes, to molluscs, and to insects, before their real character was discovered. The most common type consists of a convex, oblong body, divided transversely into three principal parts, and longitudinally into three lobes, by two deep, parallel furrows; this last character suggested the name *Trilobita*, or *Trilobites*, by which the family is now distinguished by naturalists.

These fossils are the carapaces, or shells, of crustaceans, belonging to an extinct family,‖ which comprises many

(Palæont. Soc.); and Prof. M'Coy's Synopsis of the Characters of the Mountain Limestone Fossils of Ireland.

* See Baird's British Entomostraca, p. 176, &c.

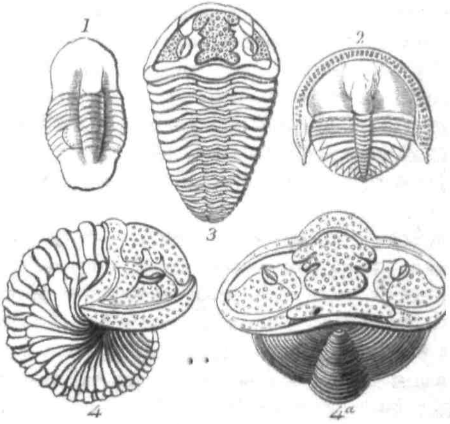
† Under the name of *Daphnia primæva*.

‡ Under the generic appellation of *Cyprella*.

§ LHWYD. Philos. Trans. for the year 1698.

‖ The Trilobites appear to have been related more nearly to the *Phyllopoda* than to any other division of the Crustacea.

genera, and numerous species. Mortimer, Da Costa, Guettard, and Linnæus recognised the crustacean character of



LIGN. 175. TRILOBITES. *Silurian Limestones.*

Fig. 1.—ILLÆNUS PEROVALIS. (*Murch. Sil. Syst.*)
2.—TRINUCLEUS LLOYDII. (*Murch. Sil. Syst.*)
3.—CALYMENE BLUMENBACHII: the upper surface of the carapace, viewed from above. *Dudley.*
4.—The same, coiled up, and seen in profile.
4a.—The same, seen in front.

this interesting, but obscure class of organic remains: their true affinities, however, were first scientifically determined by Alex. Brongniart.* Many memoirs on the *Trilobites* have since been published by eminent Continental and American writers;† and much light has been thrown on the subject by the labours of Martin,‡ Parkinson,§

* Hist. Nat. Crust. Foss. Burmeister on Trilobites; Introduction.

† A Monograph on the Trilobites of North America, by Jacob Green, M.D. Philadelphia, 1832.

‡ Petrificata Derbiensia.

§ Organic Remains of a Former World, vol. iii. See Pictorial Atlas.

Stokes, Phillips,* König,† Dr. Buckland,‡ Sir R. I. Murchison,§ and others. The beautiful illustrations and interesting description of the Trilobites in Dr. Buckland's Bridgewater Treatise (*Bd.* p. 389, and pl. xlv. xlvi.) must have rendered the reader familiar with the most important facts relating to these extinct beings; but subsequent discoveries have thrown additional light on their structure and natural affinities. The works of M. Burmeister,‖ Mr. Salter,¶ Prof. M'Coy,** and especially of M. Barrande,†† should be carefully referred to by the student in this branch of Palæontology.

In the Trilobites the head is distinct, and without antennæ, and the feet are supposed to have been rudimentary, soft, and membranaceous: the essential characters which separate them from all other crustaceans, except *Bopyrus* (a parasite on the branchiæ of the common prawn), are, according to Mr. Macleay, the deficiency of antennæ, and of lateral posterior abdominal appendages, and the presence of evanescent feet. Like other crustaceans, the Trilobites were subject to the process of metamorphosis during their early stages of life; and M. Barrande has ascertained that one species, the *Saö hirsuta*, appears in no less than twenty different stages of development. In its earliest, embryonic condition, it is a simple disk, and it passes through various stages until it becomes a perfect adult trilobite, having seventeen free thoracic segments and two caudal joints. No less than ten genera and eighteen species were instituted

* Geology of Yorkshire; and Palæozoic Fossils of Devon.

† Icones Fossilium Sectiles.

‡ Bridgewater Treatise.

§ Silurian System, chap. xlvii.

‖ Die Organisation der Trilobiten. 1843. Translation: Ray Society.

¶ In the Quarterly Journal of the Geological Society, and in the Memoirs and Decades of the Geological Survey of Great Britain.

** Palæozoic Fossils in the Cambridge Museum.

†† The Silurian System of Bohemia: the Trilobites.

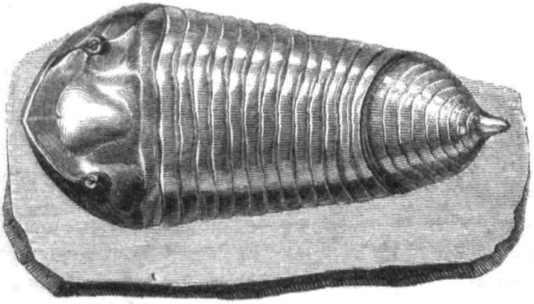
by palæontologists on *some* of the forms only which this one species presents in its different stages of metamorphosis, before M. Barrande's laborious and long-continued investigations gave him an insight into the true relations of these various conditions of the same animal to one another. This talented and indefatigable palæontologist has arrived at like results with other Trilobites, and has been enabled to add greatly to our knowledge of the natural history and geological distribution of this interesting group of crustaceans. See Transact. of the Sections, Brit. Assoc. 1849 and 1850; and *Trilob. Bohême*, pl. vii.

The *Trilobites* have been arranged in numerous genera, the names of which in a few cases are expressive of natural characters, but in others have reference to the obscurity that still invests some parts of the organization of these animals.*

CALYMENE BLUMENBACHII. *Lign.* 175, *figs.* 3, 4.—This is the Trilobite so well known as the *Dudley locust*, or *insect*. It consists of an ovate, convex, trilobed crustaceous shell, or case, and is found either expanded, as in *Lign.* 175, *fig.* 3, with its under surface attached to, and blended with, the limestone (*Wond.* p. 789); or coiled up like an *Oniscus*, or wood-louse, as in *figs.* 4 and 4^a. The head is large, convex, rounded in front, with a broad border, and divided into three lobes by two longitudinal depressions. The eyes are two in number, compound, and have numerous facets; they are situated on the sides of the head, remote from each other. The carapace is deeply trilobed by two longitudinal furrows; the thoracic portion is composed of thirteen segments; the caudal shield is small and nearly semicircular. This species is from one to four inches in length. It occurs from the Lower Llandeilo rocks up to the Upper Ludlow inclusive.

* As, for example, Asaphus, *obscure*; Calymene, *concealed*; Agnostus, *unknown*

The structure here described may be regarded as the normal type, but numerous and important modifications prevail in the different genera.



LIGN. 176 HOMALONOTUS DEPHINOCEPHALUS.
(*Reduced from* pl. vii. *Sil. Syst.*) *Upper Silurian, Dudley.*

In the genus HOMALONOTUS, *Lign.* 176, the thoracic portion of the carapace is but obscurely lobed, and consists of thirteen segments; the abdominal is distinct from the thoracic, and formed of nine rings; it terminates in a prolonged point. The *H. Herschelii* is a large Trilobite, very plentiful in the Upper Silurian schists of the Cape of Good Hope.

In another genus, ASAPHUS (*Geol. Surv. Decade* 2), the carapace is wide and much depressed; the middle lobe distinct, the cephalic portion rounded in front, and terminating posteriorly in a sharp process on each side. The eyes are compound, and each contains upward of six thousand lenses, many of which remain in some examples.* Some American species belonging to this group are of a gigantic size, as, for example, the *Isotelus gigas* (of Mr. Dekay), which is

* Mem. Geol. Surv. Decade 2, pl. v. p. 2, note.

eighteen inches long. In the Isotelus* the body is of an oval shape, and the posterior angles of the head are rounded; the thorax is composed of eight segments.

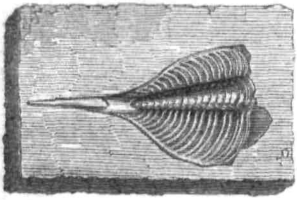
Another division of the Trilobites has the body contracted, and very thick, and the abdomen large and scutiform, without any segmentary divisions; the small crustacean (*Illænus perovalis, Murch.*) *Lign.* 175, *fig.* 1, will serve to illustrate these characters.

The Trilobite called Bumastus by Sir R. Murchison (from its grape-like form) presents a very curious modification of the normal type. Both the head and caudal extremity are rounded, with no distinct longitudinal furrows; and the whole surface of the carapace is covered by extremely thin, apparently imbricated, lamellæ, the edges of which are undulated, and the intermediate spaces studded with minute dots. The eyes are smooth, and not granulose, as in Calymene. This genus is known in England by the name of the *Barr Trilobite*, from its occurrence in the limestone near Barr, in Staffordshire; it is sometimes five inches long, and three and a half wide (*Geol. Surv. Decade* 2, pl. iii. and iv.).

The genus Ogygia (*Bd.* pl. xlvi. fig. 9) is characterised by the elliptical and depressed form of the carapace, its nearly balanced extremities, and the prolongation of the buckler, or cephalic portion, on each side, into slender spikes, distinct from the body; the thoracic and abdominal regions are divided by two deep, longitudinal furrows, into three lobes; there is also a straight, longitudinal groove, in the front of the buckler (see figures and descriptions of *O. Buchii, Geol. Surv. Decade* 2). The Trilobites of this genus are found in the Lower Silurian rocks of North Wales and Ireland; they occur also in great abundance in the slate rocks of Angers, and some species are more than a foot in length.

* *Isotelus*, i.e. equal extremities.

Some species of the genus PHACOPS have long, pointed caudal appendages, as the *P.* (formerly *Asaphus*) *caudatus*



LIGN. 177. PHACOPS CAUDATUS. *Upper Silurian. Dudley.*
The caudal extremity.

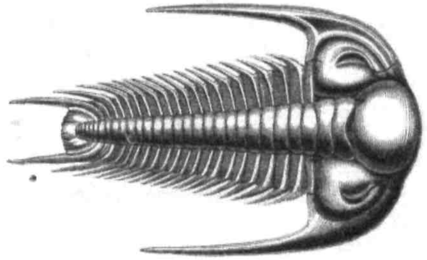
(*Lign.* 177; *Bd.* pl. xlv. figs. 10, 10′; and *Geol. Surv. Decade* 2, pl. i.). The eyes are often well preserved, and each contains about 240 spherical lenses.

TRINUCLEUS. *Lign.* 175, *fig.* 2; *Ly.* fig. 432.—This genus comprises several small forms which are found in the Lower Silurian rocks of England, and occur in the equivalent deposits of Sweden, Norway, and Russia.* In the *Trinucleus*, the cephalic shield is obtuse, trilobed, rounded, and terminating in lateral spikes; and its margin is marked by numerous pit-like depressions. There are six body-rings or thoracic segments. The caudal shield is large and somewhat triangular. There are no distinct eyes.

PARADOXIDES. *Lign.* 178.—The Trilobites of this genus are easily recognised by the ends of the lateral segments of the thorax and abdomen terminating in deflected points, which extend in spikes beyond the membrane they supported, and particularly those near the tail, which are much elongated; whereas in the other genera the lateral points of the segments are united by a membrane, which often forms a border beyond them. The cephalic buckler is semicircular, and its lateral angles are lengthened out

* Murch. Sil. Syst. p. 217.

ehind into two strong spines; it is divided on the median ne into four protuberances, by transverse grooves. The



IGN. 178. PARADOXIDES BOHEMICUS: *nat.*
Silurian. Bohemia.

horax consists of from sixteen to twenty segments; the bdominal buckler is generally very small and rounded. The animals of this genus have the body much depressed, nd the lateral lobes wider than the middle lobe: some pecies are of considerable size, attaining several inches in ength.

A very peculiar form of Trilobite (*Brontes flabellifer*, *Ly.* p. 348) is found in the Devonian strata of the Eifel nd South Devonshire; the head, or cephalic region, is arrow, and has two lunated eyes; the thoracic region is rilobed and short, and composed of about ten small articu-ations; the abdominal very small, and bordered by seg-nents, which radiate and form a wide, fan-shaped expansion. Other species of this genus occur in the Silurian rocks.

With regard to the under surface of the Trilobites much emains to be known. No decided indications either of ntennæ or extremities have been discovered. In an Ame-ican specimen, Mr. Stokes detected a plate,* which appears

* Geol. Trans. vol. ii. p. 208. See also *Bd.* pl. xlv. fig. 12; and Bur-neister, pl. vi.

to be a *labrum*, or upper mandible or lip, resembling that of *Apus cancriformis*. This animal has a similar labrum, "and lateral influted terminations of the shelly segments of the body, with a distinctly trilobed *pygidium* (tail or caudal portion), and a prolonged tail: the feet being foliaceous, and the abdomen merely covered by a membrane."* In the upper or dorsal surface of the carapace the Trilobites approach certain *Isopoda*, particularly in the characters of the buckler and eyes. Mr. Macleay states that among the existing crustaceans there are certain genera which individually possess some one or more of the characters, which have been thought peculiar to the extinct Trilobites. Thus the *Serolis* (*Bd.* pl. xlv. fig. 6), and the *Bopyrus*, have a trilobed form; the female *Cymothoæ* have the coriaceous margin of the body, and in some species are without eyes, as are many of the Trilobites; while the eyes of the males of some *Cymothoæ* are composed of large facets, and are situated on the back of the head, wide apart, as in the *Calymene*; rudimentary feet, and the absence of antennæ occur in *Bopyrus*; and lastly, the *Sphæroma* has an onisciform body, and the power of rolling itself up into a ball, like the Calymene (*Lign.* 175, *fig.* 4). The analogy between the Bopyrus and the Barr Trilobite is so close, that if the latter had a body with thirteen equal segments, and short crustaceous feet, it would be in every essential particular a male *Bopyrus*.† Burmeister regards the Trilobites as being related to the *Branchipus*. From the absence of eyes in the female, and their presence in the male of certain recent genera of crustaceans, it is not improbable that a similar character may have prevailed in the Trilobites, and that certain fossils referred to different genera, from the presence or absence of eyes, may have been the males and females of the same species.

* Murch. Sil. Syst. p. 665. † Ibid. p. 667.

The habits of the Trilobites, as deducible from Mr. Macleay's exposition of their structure and affinities, must have resembled those of the *Cymothoadæ*, some of which, like the Calymenes, coil themselves up, and are not parasitical; while their close affinity to Bopyrus, and the apparent absence of distinct crustaceous feet, imply that they were to a certain degree sedentary. The flat under surface of their bodies, and the lateral coriaceous margin of several species, which is so analogous to that of the multivalve shell *Chiton*, render it probable that they adhered by a soft, articulated, under surface, to the rocks or sea-weeds. Their instruments of progression are unknown; whether they moved by means of membranaceous feet, or by the undulations of setigerous segments, like the earth-worm, or by wrinkling the under surface of the abdomen, like the Chiton, are questions yet to be determined. It is evident, from their longitudinally trilobed form, and lateral coriaceous margin, that they had the power of firmly adhering to flat surfaces; and while thus sedentary the thin but hard dorsal crustaceous shell would protect them from the attacks of their enemies. "The Trilobites, probably, like the Chitones, adhered in masses one upon another, and thus formed those conglomerations of individuals which are so remarkable in certain rocks; but it is not likely that they were parasitical, since almost all the existing parasites that adhere to other animals, have strong feet, armed at their extremities with hooks for that purpose." * From the form of the *labrum* of the mouth (*Barrande*, pl. i. and ii A) it is inferred that they were carnivorous, preying on naked mollusks, or on the annelides, with which their remains are associated.

As the compound eyes of the *Trilobites* † are similar to

* Murch. Sil. Syst. p. 669.

† The compound eyes in many specimens remain in a high state of preservation. M. Barrande in the eye of a *Brontes palifer* counted 30,000 lenses. See also Barrande, pl. iii.

those of existing crustaceans and insects (see *Wond.* p. 792), the highly interesting and important fact is established, that the mutual relations of light to the eye, and of the eye to light, were the same in the remote epoch when the Trilobites flourished, as at the present time; and that the condition of the waters of the sea, and the atmosphere, and the relation of both these media to light, have undergone no change through the countless ages that have elapsed since the deposition of the Silurian strata.*

GEOLOGICAL DISTRIBUTION OF FOSSIL CRUSTACEANS.—We have seen that the Tertiary strata contain the remains of many of the highest organized crustaceans; a few brachyurous, macrurous, and entomostracous genera appear in the Cretaceous, Oolitic, and Liassic formations; whilst the Isopodous *Archæoniscus* and several species of Cypris occur in the Wealden and Purbeck deposits. Some few Entomostraca have been enumerated from the Trias and Permian.

One species of macrurous decapod has been found in the Muschelkalk of Germany; and Mr. Prestwich's "Apus dubius" (*Geol. Trans.* 2d ser. vol. v. pl. xli. fig. 9), and Dr. Ick's crustacean, noticed in *Journ. Geol. Soc.* vol. i. p. 199, both from the Coal Measures of England, are probably true Decapodous Crustaceans. With these exceptions not a species of the numerous tribes of Crabs, Lobsters, &c. has been observed in the older formations, though composed of such enormous thicknesses of marine detritus, and containing countless myriads of the relics of the inhabitants of the ocean.

A few species of *Limulus*, several *Cytheres* and allied genera, and a few Trilobites (*Phillipsia* and *Griffithides*)

* See Dr. Buckland's eloquent and instructive commentary on this subject, *Bd.* pp. 401—404.

belong to the strata of the Carboniferous System. In the Devonian System we find some minute entomostracans, the gigantic *Pterygotus*, and various Trilobites (*Brontes, Cheirurus, Homalonotus, Phacops*, &c.); but it is the Silurian rocks that constitute the grand mausoleum of those ancient beings, the Trilobites.

There are about thirty genera of Trilobites found in the Silurian rocks of Great Britain and Ireland. Many of these are common to the Upper and Lower Divisions of that system; and some of them are met with both in the Silurian and in the Devonian rocks, as *Phacops, Brontes, Cheirurus, Harpes*, and *Homalonotus*. The *Calymene Blumenbachii* (*Lign.* 175, *figs.* 3 and 4) ranges through the Ludlow and Wenlock, to the Bala and Llandeilo formations. The *Phacops caudatus* also (*Lign.* 177), the *Cheirurus bimucronatus*,* and the *Encrinurus punctatus* † extend from the Ludlow, to the Llandeilo formation. The Upper Silurian rocks exclusively contain some peculiar forms, as *Encrinurus variolaris, Bumastus Barriensis*, and several species of *Acidaspis*. And the Lower Silurian has several distinct genera, namely, the *Trinucleus* (*Lign.* 175, *fig.* 2), *Ogygia, Agnostus, Asaphus, Olenus, Remopleurides*, &c. One species of *Pterygotus*, and one of *Eurypterus*, the *Ceratiocaris* and *Hymenocaris*, and several species of the minute bivalved Entomostraca (*Leperditia* and *Beyrichia*) are all that remain to be enumerated as constituting, in company with the *Trilobites*, the Crustacean fauna of the ancient Cambrian and Silurian seas.‡

* In Murchison's Silurian System this form is figured (pl. xiv. figs. 8 and 9) and described as Paradoxides bimucronatus.

† This is described and figured as Asaphus tuberculatus in Buckland's Bridgewater Treatise, pl. xlvi. fig. 6.

‡ We have also to refer to the indications of the existence of other large Silurian Entomostraca afforded by the magnificent series of fossil foot-tracks lately brought to England by W. E. Logan, Esq., and obtained by that gentleman from the Potsdam Sandstone (Lower

ON COLLECTING FOSSIL CRUSTACEANS.—The Crabs and Lobsters of the argillaceous tertiary strata are generally imbedded in nodules of indurated clay and septaria. On the shore beneath the cliffs on the north of the Isle of Sheppey, and near Southend, specimens may be observed in the nodules that have been exposed to the action of the waves, the attrition to which they have been subjected having partially worn away, the surrounding stone and displayed the enclosed fossils. In these examples the carapace is occasionally seen on one side, and the pair of pincer-claws on the other face of the boulder; the other feet and the plates of the thorax may sometimes be developed in such examples by chiselling away the enveloping mass. In the laminated marls of the tertiary and other deposits, in which the minute crustaceans, as the *Cyprides* abound, thin slabs covered with these relics may be easily extracted; and many of the tertiary clays and sands yield *Cytheres*, together with *Foraminifera* and other minute fossils, on careful washing and examination with a lens.

The Chalk crustaceans, particularly those which are muricated, or beset with spines and tubercles, as the *Enoploclytia Sussexiensis* and *E. Leachii* (*Lign.* 169), require considerable patience and dexterity to develope successfully. The crustaceous covering of the carapace and claws adheres firmly to the chalk by the rough external coat, while the inner, smooth, glossy surface as readily separates. Hence upon breaking a block of chalk containing portions of these crustaceans, we find one piece exhibiting a chalk cast of the claw or carapace, covered with tubercles or papillæ, that have been moulded in the bases of the spines of the crust

Silurian) of Eastern Canada. These foot-marks and trails have been determined by Prof. Owen as being most probably referable to some large Crustaceans of the *Limulus* Group, and are named by him *Protichnites*. (See drawings and descriptions in the Quarterly Journal of the Geological Society, vol. viii.)

and on the other portion the crustaceous shell imbedded by its outer surface, and presenting the internal glossy lining, beset with circular depressions, which are the bases of the spines. This crust is exceedingly friable, and will flake off by a very slight touch. To obtain specimens with the external characters, it is necessary to proceed with great caution; and when indications of a crustacean are observed in a block, the chalk should be chiselled or sawn off to within half an inch of the surface of the fossil, and the remainder of the stone be cleared away, piece by piece, by means of a penknife or graver. By this process the fossils figured *Foss. South D.* pl. xxix. xxx. xxxi. were developed. When a fine specimen has been broken, and the shell is attached to one piece of the stone and the cast to the other, it is possible to obtain an illustrative example of the external surface, by cementing the pieces accurately together with very thin hot glue; and, when firmly consolidated, the chalk may be removed, and the spines, tubercles, and papillæ of the crustaceous covering be developed by the method previously described. A thin coating of mastic varnish will give durability to the crust, and improve its appearance; but the rich brown colour it possesses when first exposed soon disappears. The Crustaceans of the Galt are often found amongst the argillaceous and pyritous nodules flung aside in heaps where the Galt is used for brick-making.

The *Cytheridæ* of the Chalk, Galt, Oolite, &c. are to be obtained by disintegrating the matrix in water, and examining the debris, after sifting, under a lens.

The Limuli of the Coal-measures often form the nuclei of clay nodules, as in the example figured *Lign.* 172, in which *fig.* 2 represents the nodule without any external indication of its contents, and *figs.* 1, and 3, the same broken, and displaying the crustacean. Traces of the legs, branchiæ, and other appendages, should be diligently sought for in fossils of this kind, for they are more likely to be detected in such

specimens than in those found in limestone. It is possible that polished sections of the coiled-up examples of Trilobites (*Lign.* 175, *fig.* 4) would throw some light upon the nature of the hitherto undiscovered organs of locomotion and respiration of this extinct order of Crustaceans.

A FEW BRITISH LOCALITIES OF FOSSIL CRUSTACEANS.

Abberley. Silurian: *Trilobites* and *Beyrichia.*

Aberystwith, neighbourhood of. Silurian: *Trilobites.*

Arundel, Sussex. Chalk-pits in the vicinity. *Astacidæ* and *Cytheridæ.*

Atherfield, Isle of Wight. Wealden: *Cyprides* in clay (*Lign.* 174).

Barr, Staffordshire; limeworks at Hay Head. Silurian: *Trilobites,* particularly of the genus *Bumastus.*

Bewdley, Shropshire. Silurian: *Trilobites.*

Bolland, Yorkshire. Carboniferous Limestone: *Trilobites* (*Cyclus, Phillipsia*).

Burdie-house, near Edinburgh. Fresh-water coal-measures. *Cyprides* and *Eurypteri.*

Burham, near the banks of the Medway, Kent. Quarry of Mr. W. Lee, a good section of the lower Chalk: fine Crustaceans.

Coalbrook Dale. Coal-measures and Silurian. *Limuli* and *Trilobites.*

Coniston, Lancashire. Silurian: *Trilobites.*

Dinley, Wilts. Purbeck. *Isopoda* (*Lign.* 171) and *Cyprides.*

Dover. In the lower Chalk, *Astacus* (*Enoploclytia*) *Sussexiensis,* &c.

Dudley. Upper Silurian: *Trilobites* in abundance.

Durlstone Bay, near Swanage. Purbeck: *Cyprides* and *Isopoda.*

Folkstone, Kent. In Galt: small *Crabs* (*Lign.* 168), and numerous *Cytheres.*

Grays, Essex. Pleistocene: *Cyprides.*

Gristhorpe Bay, Yorkshire. Oolite: *Astacidæ.*

Hastings, Sussex, neighbourhood of. Wealden: *Cyprides.*

Hollington, near Hastings. Wealden: *Cyprides.*

Hordwell Cliff, Hampshire. Upper Eocene: *Cyprides.*

Kildare, Ireland. Carboniferous and Silurian: *Trilobites.*

Langton Green, near Tunbridge Wells. Wealden: *Cyprides.*

Lewes, Sussex. In the Chalk-pits of the vicinity: *Astacidæ* (*Lign.* 169), and other Crustaceans.

Llandeilo, Caermarthenshire. Lower Silurian: *Trilobites, Trinuclei.*

Lyme Regis, Dorset. Green Sand: *Hoploparia.* Lias: *Coleia.*
Malvern Hills. Lower Silurian. *Trilobites* (*Olenus*).
Meifod Hills, Montgomeryshire. Silurian: *Trilobites.*
Mount Pleasant, Caermarthen. Silurian: *Trilobites.*
Newton Bushel. Devonian: *Trilobites* (*Brontes*).
Rhiwlas, near Bala, North Wales. Lower Silurian: *Trilobites.*
Ringmer, near Lewes. In Galt: small *Crabs*, &c.
Sandown Bay, Isle of Wight. *Cyprides*, in Weald Clay.
Scarborough. Oolite: *Astacidæ*, in clay nodules.
Sheppey. London Clay: *Lobsters* and *Crabs.*
Steyning, Sussex. In Chalk-marl: *Lobsters*, &c.
Tyrone, Ireland. Carboniferous and Silurian: *Trilobites.*
Wenlock, neighbourhood of. Upper Silurian: *Trilobites.*
Westbury, Gloucestershire. Lias: *Estheria* and *Cyprides.*
Wilmington, near Marton, Salop. Silurian: *Trilobites.*
Wistanstow, Salop. Lower Silurian: *Trilobites.*
Worthing, Sussex. Neighbouring Chalk-pits. *Lobsters*, &c.

FOSSIL INSECTS, SCORPIONS, AND SPIDERS.

From the Crustaceans we pass by a natural transition to the other Articulata, viz. the ARACHNIDA (Scorpions and Spiders) and the INSECTA, in the last of which "the highest problem of animal mechanics is solved, and the body and its appendages can be lifted from the ground and propelled through the air" (*Owen*). The skeleton in these animals, as in the Crustaceans, is chiefly external, and consists of a hard shell or case (composed of a peculiar substance, termed *chitine*), divided into segments, and furnished with articulated or jointed hollow extremities. The head is distinct, and has a pair of compound eyes, and of jointed antennæ. To the segments that form the thorax the legs are attached, and these consist of three pieces in the hexapods (insects with six feet), each supporting a pair of feet. The wings in the flying insects are attached to the middle and third thoracic segments. The legs, or articulated appendages, are hollow, as in the Crustaceans, and contain the muscles and other soft parts. The generic and other distinctions

adopted by naturalists, to facilitate the study of this most numerous division of the animal kingdom, are founded on the structure and configuration of the antennæ and wings. The latter consist of flat membranous expansions, supported by hollow tubes or nervures; and in some orders consist of one pair, and in others of two. In burrowing insects, as the Beetle, the front pair of wings constitutes a hard case (*elytron*), which covers and protects the membranous posterior pair, when the animal is in repose or walking. The modifications of the wings furnish the characters by which the class is divided into orders. Thus the *Coleoptera* (sheathed-wings) comprise the beetles and other burrowing insects, in which the membranous wings are folded transversely beneath the *elytra*, or wing-cases. The *Orthoptera* (straight-wings), those with two pairs of wings, of which the anterior encase the others, the posterior being membranous, and folded longitudinal during repose; as the Earwig, Cockroach, Mantis, and Locusts. *Neuroptera* (nerved-wings), those with two pairs of transparent reticulated wings, as the Libellula, or Dragon-fly, the Ephemera, and the Termites. *Hymenoptera* (membranous-wings), with simply veined membranous wings, as the Gall-flies, the Bee, &c. The Cicas, Aphis, and Coccus constitute the somewhat anomalous group termed *Homoptera* (equal-wings), in which the anterior pair of wings are usually similar to the posterior in consistence, and shut up in a roof-like manner. The *Heteroptera* (different-wings) include the Nepa, Notonecta, &c. and have the anterior wings coriaceous at the base, membranous towards the point, and shutting up nearly horizontally, partly lapping over one another. *Lepidoptera* (scaly-wings) have wings covered with scales, as the Butterfly and Moth. In the *Diptera* (two-wings) the anterior pair of wings only are the instruments for flying, and the hinder pair are reduced to mere clavate appendages, as the Gnat and Fly. The Phryganeæ

(Caddice flies) constitute the order of *Trichoptera* (hairy-wings), related to the Neuroptera, but resembling the Lepidoptera in the distribution of the nervures of the wings, and in many other characters. Lastly, there remain the Wingless Insects, divisible into three orders, of which the Flea, the Parasites, and the Podura are respectively the types. With these few remarks on those durable parts of the structure of Insects which their fossil remains generally present, we must quit this part of the subject, and enter upon the examination of the relics which are the immediate objects of our present inquiry.

From the enduring nature of the elytra, segments, and articulated extremities of insects, the fossil remains of animals of this class might naturally be expected to abound in lacustrine and fluviatile deposits; this, however, is not the case, and except in a few favoured localities, fossil insects are seldom met with, and good specimens rank among the most rare and interesting of the organic remains of the Secondary formations. In certain Tertiary beds, as at Œningen, and Aix in Provence, insects of numerous species and genera have been discovered; and the cream-coloured limestone of Solenhofen, among its numerous other treasures, has yielded some fine examples of this class. The strata in which remains of insects have been found in England*

* Palæontologists are particularly indebted to the Rev. P. B. Brodie, F.G.S. for his compendious and valuable "History of the Fossil Insects in the Secondary Rocks of England" (8vo. 1845); and to J. O. Westwood, Esq. the eminent Entomologist, for the very important and interesting Observations on the Insect Remains, prefixed to the above work. In an interesting paper on the Geology of the vicinity of Ilminster, C. Moore, Esq. has noticed the numerous Insect remains of the Upper Lias of that place. Prof. E. Forbes and W. R. Binfield, Esq. have discovered Insects in the Hastings series; and Mr. Binfield, besides having most successfully searched the Upper Lias of Gloucestershire, has also detected some specimens in the Lias at Lyme. Lastly, Mr. Morris has found Insects in the Upper Lias in Lincolnshire.

are the Tertiary clays of the Bagshot series, the Hastings beds, Purbeck marls and limestones, Kimmeridge Clay, Oxford Clay, Forest Marble, Stonesfield Slate, Upper and Lower Lias, and the Coal Measures.

ARACHNIDA.

FOSSIL SCORPION (*Bd.* pl. xlvi′.).—The discovery of a fossil Scorpion in coal-shale, associated with leaves, by Count Sternberg, and of Spiders in the limestone of Solenhofen, by Count Münster, proves the existence at a very remote period of both these insectivorous families of *Arachnidans*, or spiders (*Bd.* p. 405). The fossil Scorpion was found in a block of sandy argillaceous shale, at Chomle, in Bohemia. It lies imbedded amidst the carbonized remains of leaves, and a large trifid carpolithe or seed-vessel (see *Bd.* pl. xlvi′.): by a fortunate separation of the shale, the back or dorsal carapace is shown on one surface; and the thorax, with five or six legs attached, and the abdominal segments, are exposed on the other, together with a fragment of the tail of another and larger Scorpion. The head and eyes, one of the jaws with teeth, and a portion of the skin remain (*Bd.* pl. xlvi. figs. 3, 4, 5, 6). The horny covering seems to have undergone no change; it is still elastic and translucent, and consists of two layers, both retaining their texture, and structure, and exhibiting under the microscope hexagonal cells divided by strong partitions.

FOSSIL SPIDERS.—With the numerous insects preserved in the gypseous marls at Aix, of which we shall treat hereafter, Spiders are occasionally found. A beautiful example, showing the under surface of a small spider, with the papillæ of the spinning organs protruded by pressure, from the cabinet of Mrs. Murchison, is figured, *Bd.* pl. xlvi′. fig. 12. In the beautiful lithographic stone of Solenhofen the remains of spiders are not unfrequent.

INSECTA.

Fossil Neuroptera.—Of this order, the insects of which are distinguished by their four finely reticulated membranous wings, several fossil species have been found. Some of these are referable to the family *Libellulidæ*;—insects so well known from their light and elegant figure, their beautiful and variegated colours, their large lustrous wings, and the velocity and gracefulness of their motions.

Fossil Libellulidæ. *Lign.* 179.—Of the highly organized family of carnivorous insects, the *Libellulidæ*, five

Lign. 179. Fossil Libellula, or Dragon-fly. *Solenhofen.*
(*Drawn by Mr. Joseph Dinkel.*)
In the cabinet of the late Marquess of Northampton.

or six specimens have been discovered in the lithographic limestone of Solenhofen; a beautiful specimen from that

locality is represented, *Lign.* 179. In this example both pairs of wings remain, but one wing is pressed down beneath the abdomen: the nervures of the wings are admirably preserved.

A few examples of the remains of this family have been found in the British strata. One species of *Libellula* and one of *Æshna* have been found by the Rev. Mr. Brodie in the Purbeck beds of the Vale of Wardour. Two species of *Libellula*,* two of *Æshna*, and some other allied species have been obtained by Messrs. Strickland, Buckman, Binfield, and Brodie from the Lias. The wing of the *Æshna liassina*, discovered in the Lias, near Binton, in Warwickshire, by Mr. Strickland, is two inches and ten and a half lines in length, and eight and a half lines in its greatest breadth, being one-third larger than the wing of the largest British species. See *Wond. Lign.* 119, and p. 528.

FOSSIL CORYDALIS. *Lign.* 181, fig. 2.—The wing of a remarkable fossil Neuropterous insect was discovered by me in a nodule of iron-stone, from Coalbrook Dale, and mistaken for a leaf. The specimen consists of one wing, which, as M. Audoin first ascertained, closely resembles that of the living *Corydalis* of Carolina; see *Lign.* 181, fig. 2. The membranous structure and the distribution of the nervures are distinctly preserved; on the portion figured the surface of the wing lies in relief on the stone; and on the corresponding part of the nodule, a sharp imprint remains.† I have named this fossil in honour of the eminent French savant, M. Alex. Brongniart.

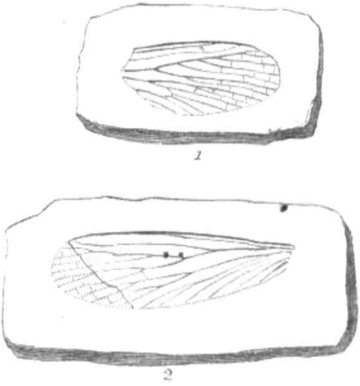
Wings of *Corydalis* have also been found in the Purbeck beds of the Vale of Wardour, by the Rev. Mr. Brodie, who

* A very interesting specimen of fossil *Libellula*, discovered by the Rev. Mr Brodie in the Upper Lias near Cheltenham, is figured in the Quarterly Geol. Journal, for 1848, vol. v. pl. v.

† This specimen is now in the collection of the British Museum.

has also discovered remains of *Phryganeidæ* and a *Termes* in the same group of strata.

PANORPA? LIASSICA. *Lign.* 180.—In the Lias, on the banks of the Severn, at Wainlode Cliff, Gloucestershire, specimens of minute neuropterous wings have been discovered. I subjoin accurate figures of two specimens in the cabinet

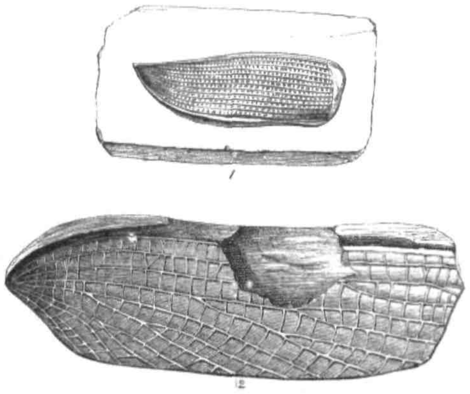


LIGN. 180. WINGS OF NEUROPTEROUS INSECTS. *Twice nat. size.*
(*Drawn by S. P. Woodward, Esq.*)
Lias. Wainlode Cliff.
Portions of the anterior wings of a species resembling PANORPA.

of the Geological Society; they are represented twice the natural size; they resemble the wings of a recent genus of Neuroptera, termed *Panorpa*; particularly *P. Germanica.* The transverse lines are not fractures, but nervures, and are faithfully copied from the originals.

To the above notice of British fossil neuropterous insects, I may add that the wing of a large species (*Hemerobioides giganteus*) has been discovered by Dr. Buckland in the Stonesfield slate.

FOSSIL COLEOPTERA.—The *elytra* or wing-cases of coleopterous insects have long since been noticed in the oolitic slate at Stonesfield, near Oxford; a locality celebrated for the only mammalian relics hitherto discovered in the Secondary strata of England. The Stonesfield elytra are always



LIGN. 181. FOSSIL WINGS OF INSECTS.

(*Drawn by S. P. Woodward, Esq.*)

Fig. 1.—ELYTRON, or wing-case of BUPRESTIS BUCKLANDI, *Great Oolite; Stonesfield.*

2.—Wing of CORYDALIS BRONGNIARTI. (G. A. M.) *Carboniferous; Coalbrook Dale.*

found detached; in no instance, I believe, has any other part of an insect been observed, except a single leg of a *Curculio* (*Bd.* pl. xlvi′. fig. 10). The specimen figured *Lign.* 181, *fig.* 1, displays the usual characters of the largest species. These fossils are of a reddish-brown colour, with a finely granulated surface; there appear to be four or five species, all of which belong to *Buprestis*, a family of beetles remarkable for their splendid metallic lustre. Remains of

Coleoptera occur in the Tertiary clays near Corfe, Dorset,* and in the Lias of Worcestershire and Gloucestershire; and in the Danby oolitic coal-pits, in the eastern moorlands of Yorkshire, the elytra of beetles have also been discovered, by Mr. R. C. Taylor (*Bd.* vol. ii. p. 78).

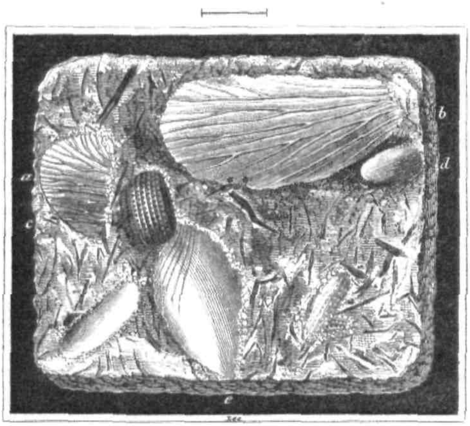
A most remarkable fossil of this kind is described by Dr. Buckland; a unique specimen of *Buprestis*, from Japan, about an inch long, *converted into chalcedony*, with the antennæ and portions of the legs finely preserved. The surface of this insect is covered with clusters of minute concentric rings of chalcedony; an appearance common in silicified shells. Associated with this fossil, were fragments of silicified wood, bored with tubular cavities, apparently by the larvæ of insects of this family; and within these cavities was a quantity of dust produced by the boring, also converted into chalcedony (*Bd.* vol. ii. p. 78).

Of the CURCULIO, a genus of coleoptera distinguished by their splendid elytra, of which the *Diamond Beetle* is a familiar example, the remains of two species have been discovered in the nodular ironstone of Coalbrook Dale, by Mr. W. Anstice, and are figured and described by Dr. Buckland (*Bd.* vol. ii. p. 76; and pl. xlvi'. figs. 1, 2). In one of these specimens (*Curculioides Ansticii*), with the exception of the rostrum and anterior part of the head, all the essential characters of the insect are displayed; namely, the elytra, thorax, and six legs, the hindmost of which exhibits the enlarged femur, or thigh, a character peculiar to the *Curculionidæ*. The legs possess a tufted appearance, which that eminent entomologist, Mr. Curtis, conceives may have been caused by fungi, after the death of the animal, as often happens in tropical climates. In the other example (*C. Prestvichii*), the insect lies on its back, with the left side raised

* See Notice by the Rev. Mr. Brodie, Quart. Geol. Journ. vol. ix. p. 51.

upwards, and exhibiting a portion of the external surface of the left elytron; there are remains of the antennæ, and indications of the proboscis and of the legs.

The *Orthoptera*, *Homoptera*, and *Diptera* are also represented in the Lias of Gloucestershire, and in the Purbeck strata of the Vale of Wardour, by numerous species, which have been enumerated, and mostly discovered, by the Rev. Mr. Brodie.* This observer has, indeed, been very



LIGN. 182. INSECTIFEROUS LIMESTONE. *Purbeck.*

(*Magnified six diameters.*)

a, *b*. Membranous wings of the *Corydalis* type.
c. Punctate-striate elytron of a Beetle.
d. Elytron of a Beetle, with a smooth surface.
e. Smooth elytron, the upper part impressed with transverse lines.

successful in his researches in the latter locality, for in the deposits of limestone and marl which yielded the isopodous crustaceans, previously described (p. 521, *Lign.* 171), he has

* See Brodie's Fossil Insects.

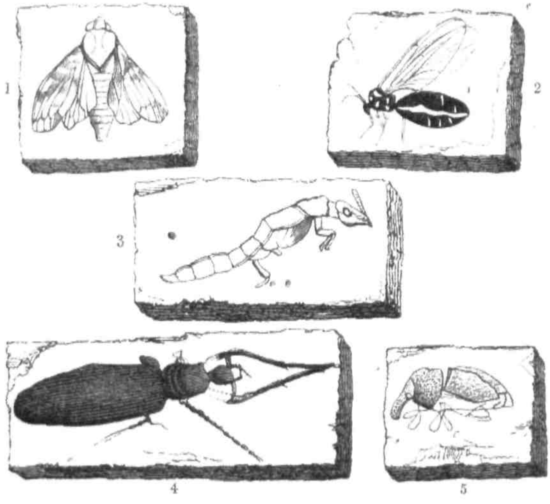
discovered the remains of several orders of insects, and states that, for abundance and variety of specimens, the beds may be said to resemble the Tertiary marls of Aix and Œningen. These remains were obtained from a quarry at Dinton, about twelve miles west of Salisbury. They con-consist chiefly of *Coleoptera*, with the remains of *Neuroptera*, *Trichoptera*, and *Homoptera*, and of several species of *Diptera*. In the cream-coloured laminated Purbeck marls that are exposed in Durlstone Bay (about one mile from Swanage) insectiferous beds have been found by the Rev. O. Fisher and Prof. E. Forbes, which are the equivalents of those of the Vale of Wardour; and similar beds were met with in the cutting of the railway through the Ridgway Hill, between Dorchester and Weymouth.

In a quarry on the road-side between the village of Stone and Hartwell, Bucks, the Portland Oolite is covered by the Purbeck marls; in these latter remains of Insects occur, together with scales and teeth of small Fishes, and abundance of *Cyprides*.

All the British localities of fossil insects have now been alluded to; but on the Continent, independently of the celebrated limestones of Solenhofen, to which reference has been made, p. 550, there are several tertiary deposits exceedingly rich in these interesting fossils.

Fossil Insects of Aix, in Provence.—The town of Aix is situated in the lowest part of a deep valley, the immediate flanks of which are composed of a thick fresh-water formation, lying unconformably upon strata of Jura limestone. The fresh-water series consists of white and grey calcareous marls, calcareo-siliceous grits, and beds of gypsum; and the quarries formed in the latter rock have long been celebrated for the prodigious quantity of fish and plants which they contain. M. Marcel de Serres first made known the great abundance of insects in these gypseous

marls, and has enumerated nearly seventy genera, chiefly of the Coleoptera, Diptera, and Hemiptera; they are mostly referable to European forms, and to existing genera. An interesting Memoir on these strata, by Sir R. Murchison and



LIGN. 183. FOSSIL INSECTS. *Tertiary.* *Aix in Provence.*

Fig. 1.—TETTIGONIA SPUMARIA.
2.—MYCETOPHILA; the body distended by pressure.
3.—LATHROBIUM.
4.—Allied to PENTHETRIA HOLOSERICEA. The hinder legs are broken off, and one of them reversed, so that the *tarsi* nearly touch the thigh; the *palpi* are long and perfect; the *antennæ* are remarkably distinct.
5.—LIPARUS; resembling L. PUNCTATUS.

Sir C. Lyell,* first directed the attention of the English reader to these beautiful fossils. In *Wond.* p. 261, an epitome of this valuable communication is given, and five

* Edinburgh New Philosophical Journal for October, 1829.

specimens of insects are here figured, which will convey some idea of their forms and perfect state of preservation.

FOSSIL INSECTS OF ŒNINGEN.—In the immediate vicinity of Œningen, near Constance, on the banks of the Rhine, there is the basin of an ancient lake, filled up with marls and limestones, presenting a fine example of a lacustrine formation, and abounding in fossil Fishes, Reptiles, Plants, Shells, Crustaceans, and Insects.* These Insects are often in an admirable state of preservation, and occur in the different stages of larva, pupa, and imago. The pupa of a *Libellula* shows the mask, insertion of the legs, and the spiracula. Some belong to genera, the species of which frequent marshy plants of the same kind as those which are found associated with the insects; and it seems probable that they fell into the lake from the plants which grew on its borders, and became enveloped in the fine mud or sediment. Numerous species of several genera of Ants also occur in these deposits of Œningen and at Radoboj in Croatia.†

FOSSIL LARVÆ OF PHRYGANEA. *Ly*. p. 185.—The *Caddis-worm*, so well known to all the brethren of the angle, is the larva of the winged insect termed *Phryganea*, and is abundant at the bottom of fresh-water streams and lakes; the cases, like those of the marine *Sabella* (p. 385, *fig*. 6), are always studded over with extraneous bodies, cemented together by a glutinous secretion to the silken integument, or case, which encloses the lava. Some species are coated with pieces of stick or straw, others with minute shells, as planorbis, bithinia, and the like; and when the larvæ have passed into the perfect state, their cases, or *indusiæ*, remain.

* See the Memoir by Sir R. I. Murchison on the lacustrine formation at Œningen, near Constance, Geol. Trans. new series, vol. iii. p. 277.

† See Prof. O. Heer's Memoir, translated in the Quart. Journ. Geol. Soc. vol. vi. pt. ii. p. 61; and his History of Insects, ibid. p. 68.

Many of the Tertiary fresh-water limestones of Auvergne are almost wholly composed of the *indusiæ* of Caddis-worms, cemented together by calcareo-siliceous matter into stone, which is employed for building, and is called indusial limestone (*Wond.* p. 273). These limestones are associated with marls abounding in fresh-water shells and cyprides; the whole assemblage presenting all the stratigraphical and zoological characters of a lacustrine formation. "If," says Mr. Scrope,* "we consider that repeated strata, of five or six feet in thickness, almost entirely composed of these tubes, once extended over a district presenting a surface of many hundred square miles, we may have some idea of the countless myriads of minute beings which lived and died within the bosom of that ancient lake."

ON COLLECTING FOSSIL INSECTS.—The localities in which the British collector may reasonably expect to discover fossil remains of Insects, are Stonesfield, where the elytra of beetles are by no means scarce,—Coalbrook Dale, in which relics of this class are sometimes, but very rarely, found in the ironstone nodules,—Bedford, Warwickshire, and the Wainlode and Aust Cliffs, for Lower Lias insects,—Dumbleton and Ilminster, for Upper Lias insects,—Dallards, near Dinton, and Stone, near Aylesbury, and the exposures of similar beds in Dorsetshire, for the Purbeck insects.

The white clays belonging to the Bagshot series of Bournemouth, Poole, and Corfe, so rich in beautifully preserved leaves and other parts of plants, should be carefully searched for insect remains, since these clays at Creech, near Corfe, have already afforded a few specimens.†

* On the Geology of Central France, by G. Poulett Scrope, Esq. 4to. 1827.

† Quart. Geol. Journ. vol. ix. p. 51.

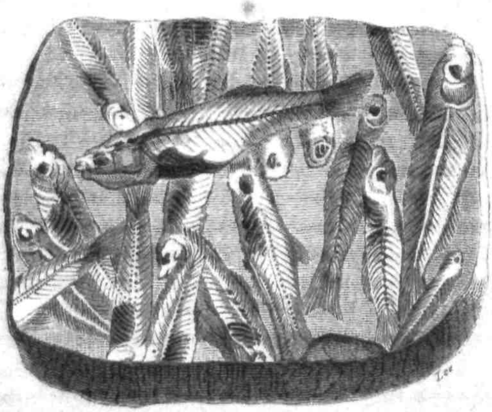
At page 549 a few other English localities yielding these delicate and very interesting fossils are also indicated as having been lately discovered by some of our most acute and active geologists.

Should the student visit the celebrated sites of these fossils in France and Germany, namely, Aix, Œningen, Solenhofen, &c., he will have but little difficulty in obtaining an interesting series, at a moderate expense.

The marls and limestones in which insects occur are often of a laminated character, and in general readily split asunder in the direction favourable for the display of the insects. In some examples, only the form of the animal is seen through a thin opaque pellicle of calcareous earth, which may be removed by a penknife or graver, and the wings, elytra, antennæ, legs, &c. will thus be disclosed. A very thin coating of mastic varnish heightens the colours of such specimens, and renders them more durable.

CHAPTER XIV.

FOSSIL ICHTHYOLOGY; COMPRISING THE SHARKS, RAYS AND OTHER PLACOID FISHES.



LIGN. 184. A GROUP OF FOSSIL FISHES. *Tertiary. Aix.*
LEBIAS CEPHALOTES (*Agassiz*).

ASCENDING from the two grand subdivisions of the animal kingdom, the *Mollusca* and the *Articulata*, we advance to the VERTEBRATA, animals distinguished from all those which have previously engaged our attention, by the possession of a bony, jointed, hollow column of support, or spine, formed of bones termed *vertebræ* (*turn or whirl bones*), and enclosing and protecting those strands or cords of the nervous

system called the spinal marrow; the former classes, being destitute of such a structure, have the general name of *Invertebrata*.

In the beings whose mineralized remains form the subject of our present investigation, the durable parts of the framework, or skeleton, are, in most instances, situated internally, and their fossil relics consist principally of the bones, or solid earthy portions of their structures, either imbedded in the rocks in their natural relative position, or in a state of dismemberment and dispersion. In most cases the teeth, and in many the durable parts of their external integument, or skin, are also preserved, in a greater or less degree of integrity.

In the lowest class of *vertebrata*, the FISHES, the skin is covered with numerous pieces or scales, of a dense, durable substance, and strengthened, in some families, by the addition of osseous plates; thus constituting a flexible and almost impenetrable coat of armour, which affords suitable protection to beings peculiarly exposed to external injuries, from the nature of the regions they inhabit, and the state of warfare with each other in which they are constantly engaged. Confined to a fluid medium, they are provided with organs fitted for aquatic respiration, called *branchiæ*, or gills, and with instruments of progressive motion, termed *fins*, by which they are enabled to propel themselves through the water with great velocity. The apparatus for seizing, tearing, and crushing their prey presents numerous and important modifications, corresponding to the habits and economy of the different genera; their teeth offering as great variety of form and structure as those of the higher orders of animals.

The cartilaginous or the osseous nature of the skeleton, and the number and position of the fins, were the characters formerly employed in the classification of Fishes; but Prof. Agassiz, conceiving the structure of the skin to afford a

natural index to the essential modifications of organization and functions, has, with great sagacity, adopted an arrangement founded upon the form and structure of the scales; and he has divided the whole class into four orders, each distinguished by essential differences in the dermal (*skin*) system. To the geologist this method has proved of inestimable value; for it is simple, easy of application, and, so far as our present knowledge extends, may be relied upon as affording accurate conclusions as to the nature and relations of the originals to which a few detached fossil scales may have belonged. Another important aid has been derived from the microscopical examination of the structure of the teeth; and a splendid work on this subject by Professor Owen has opened a wide field of palæontological investigation, which is yet but very partially explored.*

The living species of Fishes exceed eight thousand; and those found in a fossil state, and determined by M. Agassiz, already amount to upwards of one thousand five hundred; while several hundreds are still undescribed; and the rapid progress of geological research is continually adding to the number: upwards of six hundred British fossil species are enumerated. In an initiatory work like the present, it will be necessary to confine our remarks to an illustration of the mode in which the investigation of the fossil remains of the animals of this class should be conducted; and, by the elucidation of a few leading principles, prepare the student for the perusal of works expressly devoted to this branch of Palæontology.†

* ODONTOGRAPHY; or, a Treatise on the Comparative Anatomy of the Teeth; their Physiological Relations, Mode of Development, and Microscopic Structure; illustrated by upwards of 150 plates. By Prof. R. Owen, F.R.S. &c. 4to. London. 1840—1845.

† The admirable and important work entitled "*Recherches sur les Poissons Fossiles, par Louis Agassiz,*" stands preeminent in this department of science. It consists of five volumes, 4to. of letter-press, and five volumes, folio, of coloured plates. It must be consulted by

The fossil remains of fishes rank in the first class of the "Medals of Creation," for they demonstrate the existence of numerous tribes of highly organized beings in some of the *most ancient fossiliferous strata, and the continuance of the same* type of organization, variously modified, through the entire series of subsequent deposits to the present time. Each geological formation contains peculiar groups of fossil fishes, distinguished by distinct modifications of structure. Thus, according to the data at present obtained, all the osseous fishes anterior to the Chalk belong to genera which have no representatives among existing species; and they are characterised by rhomboidal scales covered with enamel.

The state of conservation in which the fossils of this class occur, appears to have depended on the relative delicacy or firmness of the original structures, and on the nature of the deposits in which the fishes were imbedded. Thus the fossil fishes of the early formations, which are characterised by their dense integument and enamelled scales, often present the entire forms of the originals, and generally considerable portions of the connected scales, with the fins and other appendages: while the specimens of later deposits, which contain a large proportion of species with delicate scales, more often display the mineralized osseous skeleton, than the dermal structure. Sedimentary strata composed of mud or fine detritus, of whatever age, have been most favourable to the preservation of the entire forms; hence we often find in the pulverulent clays and marls of the Tertiary strata, in the Chalk of England and Westphalia, and in the fine lithographic stone of Solenhofen, fishes perfect in form, and not only individuals, but groups, with the scales, fins, head, teeth, and even the capsule of the eye, in their natural positions. A small slab of marl from Aix, in Provence, in

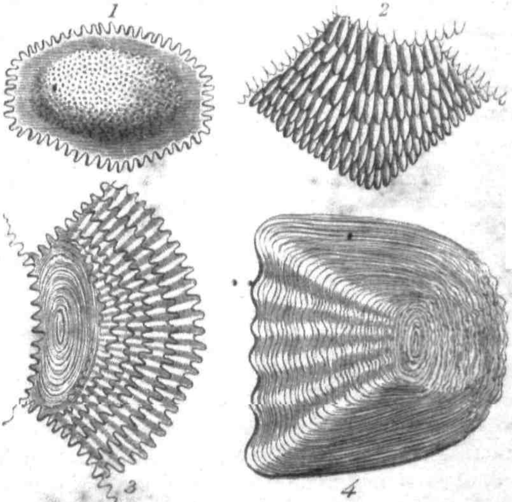
all who would acquire a correct view of the present state of fossil Ichthyology. *It is from this work that the commentary in the text has been chiefly derived.*

the collection of Sir R. I. Murchison, contains scores of small fishes, as perfect as if recently imbedded in soft mud: a portion of this specimen is represented, *Lign.* 184; and the beautiful fish figured in the frontispiece of vol. i. (pl. i. fig. 3), from near Castellamare, will serve to illustrate the state of perfection of some of the ichthyolites of the Jura limestone. In the Chalk, many of the fishes are uncompressed, the body being as perfect in form as if the original had been surrounded by soft plaster of Paris while floating in the water. But in coarse limestones and conglomerates,—in other words, in materials that have been subjected to the action of the waves and torrents,—detached teeth, scales, bones, &c. constitute the principal vestiges of this class of beings.

In illustration of this department of Palæontology, it will be expedient to consider,—1stly, the characters afforded by the scales and dermal appendages; 2dly, the teeth, or dental organs; 3dly, the osseous and cartilaginous skeletons; and lastly, apply the data thus obtained to the elucidation of some of the principal fossil genera and species.

SCALES OF FISHES.—The dermal plates or scales are composed of two substances, disposed in laminæ or plates; the one cartilaginous or horny,—the other dense and osseous, possessing the structure of bone. In most species the scales are imbricated, *i. e.* lie over each other like the tiles of a roof; the margin of a front row partly covering the series immediately behind. From this arrangement, the apparent shape of the scales is very different from their true form; the processes of attachment and the lateral angles being concealed. The scales that are not imbricated are either very small, and imbedded in the substance of the skin so as to be imperceptible to the naked eye, as in the shagreen of *Sharks;* or are disposed in the form of bosses or scutcheons, as in the Rays; sometimes bristling equally over the surface of the body, as in the *Diodon;* and sometimes covering it

like mosaic work; or forming particular series on certain regions of the body, while the other parts are garnished with different scales, as in the *Sturgeon*. There are a few genera destitute of scales. In almost all fishes there is a particular series disposed in a gently undulated line along



LIGN. 185. FOSSIL SCALES OF FISHES. (*highly magn.*) *Chalk. Lewes.*
Fig. 1.—Scale or plate of the *shagreen* of a SHARK.
2.—Scale of MACROPOMA MANTELLI; the exposed surface.
3.—Scale of BERYX LEWESIENSIS: the exposed surface.
4.—Scale of OSMEROIDES MANTELLI; the entire form.

each side of the body, from the head to the tail, and constituting what is termed the *lateral line;* these scales are tubular, and serve an important purpose in the economy of these animals. Every one must be aware that the body in most living fishes is constantly covered with a kind of mucus, or slime, which serves to lubricate the skin and to

defend it from the action of the surrounding medium. This fluid is secreted by a mucous canal or duct, which extends along the body, and ramifies in all the bones of the head, jaws, &c. ; and it is distributed over the surface of the head by numerous pores in the bones, and over the body by the tubes formed by the row of scales above described.

The four orders into which this grand class of vertebrata is divided by M. Agassiz, are founded upon the peculiar structure of the scales ;* and are characterised as follow :—

Order I. PLACOID (*a broad plate*).—The skin covered irregularly with enamelled plates, sometimes of a large size, but frequently in small points, as the shagreen on the dermal integument of the *Sharks*, and the tubercles of the *Rays*. *Lign.* 185, *fig.* 1, a fossil *placoidian* scale from the skin of a shark, highly magnified.

Order II. GANOID (*splendid*, from the brilliant surface of the enamel).—The scales are of an angular form, and composed of plates of horn or bone, covered with a thick layer of enamel; their structure is identical with that of the teeth. The *Sturgeon* is an example of this order. *Lign.*196, *figs.* 1, 2, 3, 4, are fossil scales of a *ganoidian* fish.

Order III. CTENOID (*toothed, or comb-like*).—The scales are formed of plates, which are toothed or pectinated on their posterior margin or edge, like a comb. As the plates are superimposed on each other, so that the lowermost always extend beyond the uppermost, their numerous sharp points or teeth render the scales very harsh to the touch. The *Perch* belongs to this order. *Lign.* 185, *fig.* 3, represents a fossil *ctenoidian* scale.

Order IV. CYCLOID (*circular*).—The scales are composed of simple laminæ, or plates of bone or horn, without enamel, and have smooth borders; but their external surface is often ornamented with markings. The scales of the lateral line consist of funnels placed one within the other; the contracted part of which, applied against the disk of the scale, forms the tube through which the mucus flows. To this order belong the Mullet, Salmon, and Carp. *Lign.* 185, *fig.* 4, is the scale of a fossil *cycloidian* fish.

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* For illustrations of the scales of fishes, see *Wond.* p. 339, *Lign.* 68, and p. 340, *Lign.* 69; *Foss. Brit. Mus.* p. 419; and *Ly.* fig. 306, figs. 342—347, &c. And for their minute structure, see Prof. Williamson's important paper in the *Phil. Trans.* for 1851.

FINS OF FISHES.—As the progression of fishes through the water is principally effected by the action of the tail, they have no limbs commonly so called. The instruments for balancing the body, and for assisting progression, are the fins, which are composed of numerous rays that support a membranous expansion; and the number and situation of the fins present various modifications in the different orders and genera.

The fins are named according to the situation they occupy; for example, *pectoral*, those on each side of the chest, and which correspond to the anterior extremities of other vertebrated animals; *dorsal*, on the back; *ventral*, on the belly; *caudal*, on the tail. (See outlines of Fish, *Ligns.* 186, 187, 195.) The rays are of two kinds; 1st, the *Spinous* rays; these consist of a single osseous piece, usually dense and pointed, sometimes flexible and elastic, and divided longitudinally (*Ligns.* 188, 196); 2d, *Soft* or *articulated rays*, which are composed of numerous small articulations or joints, and divide into branches at their extremities. Many species of fishes have four fins; others six; some but two; and in certain genera they are altogether wanting. In a fossil state the fins are often beautifully preserved; even the soft rays in many of the Tertiary marls and in the Chalk, are found entire, and attached to the body in their natural situation. The large, strong, spinous rays of the dorsal fins of the cartilaginous fishes, as the *Sharks* and *Rays*, are generally found detached, or connected only with a few vertebræ; but they are so abundant in some of the Secondary deposits (and in numerous instances they are the only vestiges of extinct species and genera), that they possess great geological interest; they are distinguished by the term *Ichthyodorulites* (*fossil fish-weapons*), under which head they will hereafter be described (see *Lign.* 188). The first ray in the dorsal fin of some fishes is protected in front by a double

row of enamelled scales, and these often occur in a fossil state (see *Lign.* 196, *fig.* 5).

TEETH OF FISHES.—Of all the durable parts of animals which occur in the mineral kingdom, the teeth of fishes present by far the most numerous, varied, and striking modifications of form, structure, composition, mode of arrangement, and attachment; and yet these dental organs, separately considered, do not in many instances, either in their structure or mode of implantation, afford characters by which the natural affinities of the original can be satisfactorily ascertained; and without the aid of other parts of the skeleton it is often impossible to determine, from external characters only, whether an unknown form of tooth belonged to an animal of the class of Fishes or of Reptiles. Although the modifications of form are almost innumerable, they are referable to four principal types; namely, the conical, the flattened, the prismatic, and the cylindrical.*

The conical teeth are extremely variable in size and form; some are slender, almost invisible points, distributed like the pile of velvet (*villous-teeth*), or set like the hairs of a brush (*brush-teeth*); some are long and slender, or barbed at the point; others are obtuse; and many are long and striated at the base, and closely resemble the teeth of certain reptiles. The depressed teeth are equally diversified; some have the grinding surface smooth; others, deeply grooved; in some it is flat; in others convex. In form they are either lozenge-shaped, elliptical, square, oblong, semilunar, &c. The cylindrical teeth are hemispherical, or flattened; in some fishes they are short and thick; in others slender, and support an obtuse, conical crown. The prismatic form

* The "ODONTOGRAPHY" of Professor Owen should be consulted by those who would thoroughly comprehend this interesting department of science. See also the *Article* TEETH, by Prof. Owen, in the Cyclopædia of Anatomy and Physiology.

is equally modified; from the compressed, sharp, lanceolate, cutting teeth, to the strong, triangular, three-pointed dentary organs.*

The mode of arrangement and attachment of the teeth, is as diversified as their forms. In some species all the teeth are of one type, and disposed in somewhat of a serial order on both sides of the jaws; but in a large proportion of fishes there are several kinds of teeth, which are implanted not only in the jaws, properly so called, but on the bones which form the cavity of the mouth, the arches of the palate, tongue, &c.; and it is peculiar to this class of vertebrata to present examples of teeth developed in the median line (*along the middle*) of the mouth, as in certain species, of Rays; or crossing the symphysis (the *front line of union* of the two sides) of the lower jaw, as in *Myliobates*† (see *Lign.* 194, *fig.* 2). In some species the teeth are implanted in sockets, to which they are attached only by the soft parts, as in the rostral teeth of the *Sawfish;* some have hollow bases, supported upon bony prominences, which rise from the base of the socket; as in several fossil teeth from the Chalk. "But by far the most common mode of attachment is by a continuous ossification between the dental pulp and the jaw,"‡ the teeth being thus anchylosed to the bone. In the Sharks the osseous bases of the teeth are attached by a ligamentous substance to the tough, dense crust, which covers the cartilaginous jaws; the teeth of these fishes are therefore generally found detached in a fossil state, in consequence of the decomposition of this substance.

The teeth are composed of a dense, osseous material, of a finely tubular structure, termed *dentine;* which, in many species, forms on the external surface of the tooth a layer of

* For illustrations of the teeth of fishes, see plate iv. figs. 1, 2, 8, 10, and *Ligns.* 189, 191—194, 197, 198, 202, 205; *Foss. Brit. Mus.* p. 449; and *Ly.* figs. 236, 308, 324, and 383.

† Odontography, p. 5. ‡ Op. cit. p. 6.

firmer texture, with a glossy surface, resembling enamel. The essential character of their organization is to have a pulp or medullary cavity, or cavities, filled with a plexus of blood-vessels and nerves, from which the minute tubes composing the dentine radiate.* The differences observable in the size, mode of ramification, and distribution of the medullary cavities or canals, and the *calcigerous tubes*,† as revealed by microscopic exploration, constitute important distinctive characters; particularly in the examination of the fossil teeth of extinct fishes. In some teeth the dentine is traversed by equidistant, parallel, medullary canals; in others, these channels frequently subdivide, and their branches anastomose with each other. In some the medullary canals form a reticulated, or net-like structure in the dentine, the meshes of which are occupied by calcigerous tubes, and cells; often producing a dendritical appearance, as in the tooth of a fossil fish named *Dendrodus*. "In the highest type of structure, the dentine consists of a simple medullary cavity or canal, and a single system of calcigerous tubes, which radiate from the central or sub-central pulp-cavity, at right angles to the periphery of the tooth" (*Owen*), as in the teeth of the extinct Sauroid (*lizard-like*) fishes. A continued succession of teeth takes place during the life of the fish, and we often find in fossil specimens a series of successional teeth beneath the row in use; as in the fragment of a jaw of *Lepidotus*, from Tilgate Forest, *Lign.* 197.

SKELETONS OF FISHES.—The skeletons of the animals of this class differ so remarkably in their relative degree of firmness and elasticity, in consequence of peculiar modifications of their constituent substance, as to form two grand divisions; one of which is termed the *osseous*, the other the

* See Owen's Odontography; and Tome's Dental Physiology.

† *Calcigerous tubes*; so named because they are composed of *calx*, or lime.

cartilaginous. The essential difference in the skeletons of these two groups consists in the presence or absence of earthy matter (*phosphate and carbonate of lime*) in the materials of which they are constructed. In the cartilaginous fishes, the skeleton is cartilaginous and transparent; but in some species, the skin has dense osseous particles or plates on the skin, as in the *Rays*; and in others, the head and body are protected by large osseous scutcheons, as in the *Sturgeon*. There is also an intermediate group of fishes, termed the *fibro-cartilaginous*, in which the skeleton contains lime, but in a much less proportion than in the true osseous fishes. In some genera, certain portions of the skeleton, as the bodies of the vertebræ, are cartilaginous, while the spinous processes, ribs, &c. are osseous; these characters are of considerable importance in the investigation of the fossil remains of fishes, as we shall hereafter have occasion to demonstrate.

The skeleton consists of the *cranium* or skull, which is composed of numerous bones,—the jaws, and bones of the tongue,—the osseous frame-work of the organs of respiration, consisting of the bones, rays, and arches that support the gills, and the *opercula*, or covers which close over the branchial apertures,—and of the vertebral column, formed of numerous dorsal and caudal vertebræ, with the ribs and other appendages; there are no proper cervical vertebræ, or spinal bones of the neck.

The branchial arches are in general four or five on each side, and are attached above to the cranium, and below to a chain of small bones, by which they are connected with the *os hyoides*, or bone of the tongue. The opercular bones, composing the cover or lid of the opening of the gills, consist of three pieces on each side, and are distinguished by the names, *opercular*, *pre-opercular*, and *sub-opercular*, according to the situations which they respectively occupy.

The *vertebræ* are double hollow cones,* not unlike an hour-glass in form: the interval between two of these bones is filled up, in the living state, by a gelatinous fluid. Along the upper part of each vertebra, there is an annular cavity, which in the united vertebral column forms a canal for the spinal marrow; the posterior dorsal and caudal vertebræ have also a channel below, for the passage of the large blood-vessels.

There are likewise bones analogous to some of those which enter into the composition of the extremities, chest or thorax, and pelvis of the higher vertebrata; but which it is not necessary for our present purpose here to describe.

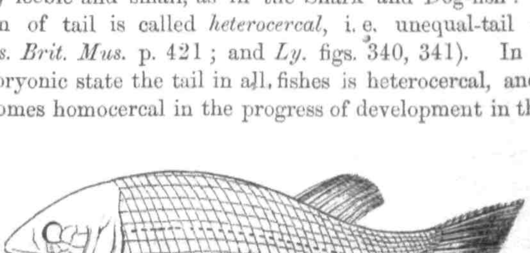
Of the organs of vision some fossil remains also occur. The sclerotic coat, or capsule of the eye, being bony in fishes, is often preserved; and in several chalk specimens I have found it occupying the orbit.

In addition to those durable parts of fishes, already mentioned, as likely to be met with in a fossil state, the bones called *otolithes* (ear-stones) must be enumerated. These calcareous bodies are found in the membranous labyrinth of the organs of hearing; and, although more or less developed in the ear-bulb of all animals, they are larger and of more definite forms in the higher osseous and cartilaginous fishes. The *otolithes* are supposed to assist in communicating more vivid impressions of sounds to the extremities of the auditory nerves; they are stony in most aquatic animals, and friable or pulverulent in those that live on land. Smooth, oblong otolithes are not uncommon in the Crag deposits of Norfolk and Suffolk; and minute ear-bones are found in the Barton Clay.

TAILS OF FISHES.—The tail, as we have previously men-

* There are certain exceptions; thus in the *Lepidosteus* the vertebral column is a series of ball-and-socket joints, the convexity being anterior, as in the land Salamander, and in the fossil reptile known as the Streptospondylus.

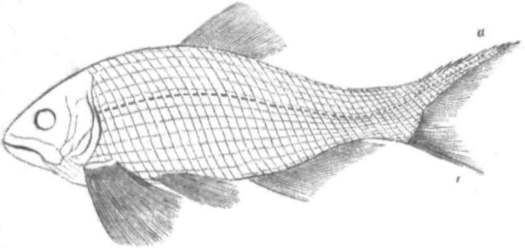
tioned, is the chief instrument of progressive motion in these animals; it assumes two principal modifications. In the greater number of the existing species the vertebral column terminates in a triangular plate of bone (formed by the fusion of the last few vertebræ), to which the caudal fin is attached symmetrically; and its figure is either rounded, or divided into two equal lobes or branches; these tails are termed *homocercal*, i. e. even-tail. In the second modification the vertebral column towards its extremity diverges from a straight line, rises up, and is prolonged into the upper lobe of the tail; the caudal fin appearing like a rudder, and its lower lobe, being destitute of vertebræ, is proportionably very feeble and small, as in the Shark and Dog-fish: this form of tail is called *heterocercal*, i. e. unequal-tail (see *Foss. Brit. Mus.* p. 421; and *Ly.* figs. 340, 341). In the embryonic state the tail in all fishes is heterocercal, and it becomes homocercal in the progress of development in those



LIGN. 186. LEPIDOTUS. *Wealden.* (⅙ *nat. size.*)
(Showing the Homocercal Tail.)

genera which have this type of the caudal appendage. But few of the existing species have the heterocercal tail, while it is found in all the fossil fishes that occur in the ancient secondary strata; namely, the Magnesian limestone, and antecedent deposits. The rounded and equal-bilobed, or homocercal, tails, are seen in the fishes from the Chalk, *Wond.* pp. 347, &c.; and in the Wealden Lepidotus, *Lign.*

186; and the unequal or heterocercal tail is shown in the Amblypterus from the Carboniferous strata, *Lign.* 187.



LIGN. 187. AMBLYPTERUS. *Carboniferous.* (¼ *nat. size.*)
a. The heterocercal tail.

In the Annals of Nat. Hist. for 1848, p. 304, Prof. M'Coy has described and figured an intermediate form of tail, which he regards as characteristic of the *Diplopterus* (of the Old Red Sandstone) and its allies: this the Professor terms the *Diphycercal* tail.

From this brief summary of the essential characters of those durable parts of the organization of fishes, which most frequently occur in a fossil state, we pass to the investigation of some illustrative examples of this class of organic remains. But before describing any entire specimens, it will be expedient to notice the separate fins, and teeth, which abound in many deposits; in some instances occurring in connexion with other parts of the skeleton, but more generally detached, and constituting the only evidence of the existence of numerous extinct species and genera. The greater part belong to the first order—the Placoidians (*Poiss. Foss.* tom. iii.), and to the families of *Sharks* and *Rays.* The osseous dorsal rays of cartilaginous fishes (named *Ichthyodorulites* (*fossil-fish-weapons*) by Dr. Buckland and Sir H. De la Beche) first demand our notice.

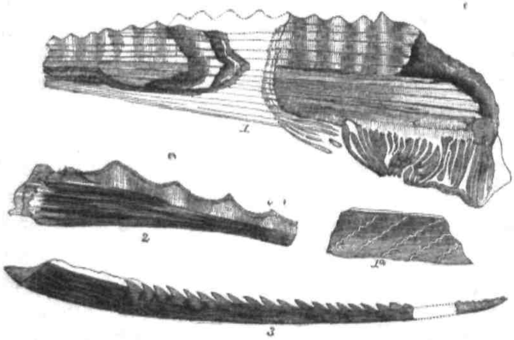
ICHTHYODORULITES. *Lign.* 188.—This name is applied

to the fossil spines, or rays, of dorsal fins, of which numerous species occur in the Secondary deposits; they belong, for the most part, to extinct cartilaginous fishes of the *Cestraciontidæ* and *Hybodontidæ* groups. In the osseous tribes the dorsal spines have at their base two articular processes, by which they are united to the osselets that support them, as in the *Silurus;* but in the cartilaginous, they have no articulations at the base, and terminate in an obtuse point, which is implanted in the flesh; the posterior margin is grooved almost to the upper extremity. They are of a fibrous, osseous texture. The common *Spinax*, or Dog-fish (*Acanthias vulgaris*), has a spine of this kind in the front of each dorsal fin. The rays of the Sharks are compressed, and some have rows of teeth on the posterior margin; in the genus *Cestracion* (Port-Jackson Shark), these organs are strong, triangular, straight, pointed, rounded in front, flat at the posterior face, and widest at the base; in the *Rays* they are flattened or depressed.

These spines are generally capable of being elevated and depressed, and not only serve the purpose of defence, but, in many instances, afford support and protection to the soft rays of the fin; forming, as it were, a moveable mast, by which the sail can be spread out or lowered at pleasure.

In illustration of this subject, I would first direct attention to the beautiful fossil, figured *Lign.* 188, *fig.* 1, which was discovered in the Chalk near Lewes, and is figured, of the natural size, *Foss. South D.* tab. xxxix. This ray, or spine, belongs to one of the Cestraciont fishes (*Ptychodus*), whose teeth are so abundant in the Chalk, and will presently be described. It is composed of fourteen thick, flat, osseous rods, or strands, intimately united together, with longitudinal furrows or sutures on the surface. The anterior margin is embossed, and the projections form on the sides wide, rounded ribs, and transverse depressions. Towards the base of the posterior part, there are large osseous

fibres, inserted vertically and obliquely, which appear to have been processes of attachment. The rods, or plates, are parallel with the posterior margin, and each terminates in a rounded extremity, or boss, on the front edge of the spine. This ray is wider at its base than at the superior part; the anterior margin is oblique, and the posterior straight. The surface, where entire, is covered with a dense osseous substance, which is finely engrailed.*



LIGN. 188. DORSAL RAYS OF SHARKS. *Sussex.*

Fig. 1.—PTYCHODUS SPECTABILIS. ¼ *nat. Chalk. Lewes.*
1a.—Portion of a DORSAL RAY, with oblique serrated sutures. *Chalk. Lewes.*
2.—PTYCHODUS GIBBERULUS. ½ *nat. Chalk. Lewes.*
3.—HYBODUS SUBCARINATUS. *nat. Weald. Tilgate Forest.*

In 1850 I discovered in the Plastic Clay of Castle Hill, Newhaven, a dorsal fin of Ptychodus, with eight vertebræ. A nearly entire fin-ray of this species, three feet in length,

* This specimen is figured in *Poiss. Foss.*; but it is represented too short, from the two portions being drawn as if they were connected, without any interval between them, as in *Lign.* 188. It is in the British Museum. See *Petrifactions*, p. 450.

has recently been discovered by Mr. Charles Potter, of Lewes, in the Chalk near that town. The remains of another ray, of equal proportions, were found near it; and these dorsal spines might have belonged to the same individual, for there are no reasons to forbid the supposition that the Ptychodus had two dorsal fin-rays. The length of these spines necessarily indicates a very large fish.

A smaller species of Ichthyodorulite, also found in the Lewes Chalk, is distinguished from *P. spectabilis* by its osseous plates contracting towards their extremities, and terminating more suddenly on the front margin, producing gibbosities less acute and more distant than in *P. spectabilis*; this species is named *P. gibberulus*: see *Lign.* 188, *fig.* 2.*

The bony plates of these fins are occasionally found lying in irregular groups in the Chalk, as if the fin had partially decomposed and the plates separated. In one example, the rays are split asunder by a piece of bone, apparently a portion of a long pointed tooth, firmly impacted between them; as if the fish had been seized by some enemy, and had escaped, with the tooth of its adversary in its fin. Very fine specimens have been found at Charing, Kent, by W. Harris, Esq. F.G.S.

In the fragment of an Ichthyodorulite from the Lewes Chalk, a remarkable structure is displayed; the osseous plates are united laterally by smooth, longitudinal lines, as in those above described; but they are also traversed by numerous oblique, finely-serrated sutures. *Lign.* 188, *fig.* 1*a.*

The Chalk contains rays of other species of *Ptychodus*, as well as of some allied genera. Of these, the most remarkable are smooth, arched, pointed spines, having a shallow posterior groove, with an enamelled surface, marked with fine longitudinal striæ, and frequent, parallel, oblique lines. These, according to Sir P. Egerton, belong to a true

* This fossil is figured of the natural size, Foss. South D. pl. xl. fig. 3.

Cestracion (see p. 584): they were first figured and described by me (*Foss. South D.* tab. xxxiii. fig. 5) as belonging to the *Acanthias major*, and were subsequently assigned to the genus *Spinax* by Prof. Agassiz (*Poiss. Foss.* iii. p. 62).

It may be necessary to remark, that the fins first described have been referred to the fishes which yielded the large grooved teeth so common in the Chalk (see *Pl. VI. fig.* 2), in consequence of their affinity to existing species, which have similar fins and teeth; and from the circumstance that the Sharks of the genus *Lamna*, whose teeth also abound in the Chalk, have no dorsal rays of this kind: still the proof of identity remains to be discovered. In one specimen only have I observed indications of any other part of the skeleton; it is a spine of *Acanthias major*, the base of which rests on several dorsal vertebræ (*Foss. South D.* tab. xxxiii.).

HYBODUS SUBCARINATUS. *Lign.* 188, *fig.* 3.—The fishes of another extinct genus of Sharks, termed *Hybodus*, from the gibbous form of the teeth, were also provided with dorsal spines, which may be readily distinguished from the preceding. These Ichthyodorulites are generally long, slightly arched, and terminate in a point at the extremity; the base, which was implanted in the flesh, is deeply grooved, and much prolonged, being sometimes equal to one-third of the entire length. The surface is marked with strong longitudinal ridges, parallel with the anterior margin, which is rounded and laterally compressed. The posterior edge, which is more or less flat, has, towards the base, two rows of sharp arched teeth, which gradually approach each other, and blend into one line on the upper part of the ray. There are numerous species of this genus in the Oolite and Lias. I have found one species in the Chalk, and a few in the Wealden. The small Ray figured *Lign.* 188, *fig.* 3, is from Tilgate Forest, and displays the usual characters of these fossils. From specimens discovered in the

Lias, associated with the teeth, it appears that the *Hybodus* had two dorsal fins, each furnished with rays, as in the recent Dog-fish.

The microscopic structure of these rays is stated by M. Agassiz to resemble that of the teeth : in some there is a pulp cavity, which occupies the centre of the spine, and is surrounded by dentine, in which the calcigerous tubes radiate direct to the surface ; the external enamel is a layer of dentine, in which the medullary canals are wanting.

In the strata below the Lias there are numerous Ichthyodorulites, some of a large size, belonging chiefly to the Cestracion family, and of extinct species, not observed in more recent deposits. Thus there are several species of dorsal rays (named Onchus, from their hooked form,) that are wide at the base, and bent backwards, with the posterior margin destitute of teeth, in the Carboniferous, Devonian, and Silurian formations ; also immense compressed spines, having small teeth on the posterior margin, and the surface covered with longitudinal striæ, and finely toothed, transversely ; hence termed Ctenacanthus, or pectinated-spine (*Murch. Sil. Syst.* p. 596).

The fossil spine, named Orthacanthus (*Poiss. Foss.* vol. iii. pl. xlv.), and found in the Coal of Manchester, has been discovered in connexion with the body of the fish to which it belonged in the Carboniferous deposits of Ruppersdorf in Bohemia (*Geol. Journal*, vol. v. part ii. p. 23).

Some Ichthyodorulites have the surface richly ornamented with stellular tubercles, and are termed Asteracanthus, or starry-spine ; there are very large fin-rays of this kind in the Wealden, Purbeck, Oolites, and Lias.*

The Ichthyodorulites of the *Rays* have no cavity like those of the *Sharks*, and are of a depressed form, and more or less flattened ; they are armed with teeth along their

* For particular information on Ichthyodorulites, consult *Poiss. Foss.* tom. iii. chap. i. About seventy species are enumerated.

exterior margins, and not on the posterior edge, as in the latter family.

FOSSIL TEETH OF FISHES.—From the durable nature and striking appearance of many of the fossil teeth of fishes, and their prodigious numbers in some deposits, they are familiar objects to the collector. By far the largest proportion of the detached teeth belongs to various species and genera of that most numerous, and widely distributed family of voracious fishes, the SHARKS. In the Tertiary strata teeth of this kind occur of a very large size; in the Chalk many species abound, particularly of the lanceolate and compressed forms, and of the rugous, mammillated, palatal teeth, commonly termed *palates*. As we pass to the more ancient formations, teeth of different forms prevail; and those which approach the recent types are either very rare, or altogether absent. We will select some examples of the different genera in illustration of this subject; the previous observations on the form and structure of the recent teeth render but few introductory remarks necessary.

FOSSIL TEETH OF SHARKS.—The fishes of the Shark and Ray families belong to the *Placoid* order; the scales in the former consist of enamelled plates and tubercles, forming a *shagreen* surface; and in the dermal integument of the latter they appear as spines and bosses, irregularly disposed.

Notwithstanding the diversity in appearance of the teeth of Sharks, they all possess one essential character of structure, namely, a base, or osseous root of variable form, which is implanted in the integuments; and a crown, or external portion, which projects into the mouth, is covered with enamel or compact dentine, and assumes numerous modifications, by which the fossil genera are characterized. These teeth are never imbedded in sockets, nor united to the dentary margins of the jaws; they only adhere to the integuments of the mouth, and the covering of the maxillæ; they possess, in most of the Sharks, great mobility. They

are generally disposed in rows; the anterior ones, being first used, fall out, and are replaced by those on the inner series. New teeth are also continually formed behind those in use, and advance successively towards the anterior rows as the latter are shed, and in their turn occupy the front rank. (See Cyclop. Anat. *Art.* TEETH.) An examination of the fossil and recent teeth of Sharks and Rays proves that the prevailing existing generic types have but few, if any, representatives in the fossils, except in those which belong to the Tertiary and Cretaceous formations; while the genera that appear isolated, as it were, in the present seas have numerous analogues in the Secondary strata.

The fossil teeth of this family may be divided into two grand divisions; namely, those which are more or less of a polygonal, obtusely conical, or depressed form, having a tesselated arrangement in the mouth; and those of a triangular, lanceolate shape, with cutting, or serrated edges, disposed in a series of rows on the jaws. The teeth of the first group (*Cestracionidæ*) have most analogy to those of the living genus CESTRACION (*Port-Jackson Shark*); the second (*Squalidæ*) to the SHARKS, commonly so called.

The *Cestracion* is the only living representative of a family of squaloid fishes of a peculiar type, whose remains occur in almost the earliest fossiliferous deposits; it inhabits the seas of New Holland and the southern coasts of China. The jaws of the Cestracion are relatively very large, and are armed with numerous rows of teeth, essentially of two kinds; those situated anteriorly, or towards the front of the mouth, being adapted for seizing and retaining the food, and the posterior ones for crushing and bruising. The prehensile teeth are sharp, angular, and pointed; the others are obtuse, polygonal, enamelled, and disposed in oblique rows along the margins and inner surface of both jaws: there are sometimes sixty in each jaw (see *Bd.* ii. pl. xxvii^{d}. fig. A). Fossil teeth of this type are exceedingly numerous in the Chalk, Lias, &c. but are very seldom found in juxta-

position; the decomposition of the cartilaginous integuments in which they are imbedded, having, in most examples, occasioned their displacement and dispersion; specimens, however, are occasionally discovered, in which numerous teeth, of various sizes, are disposed in mosaic, in their natural relative positions.

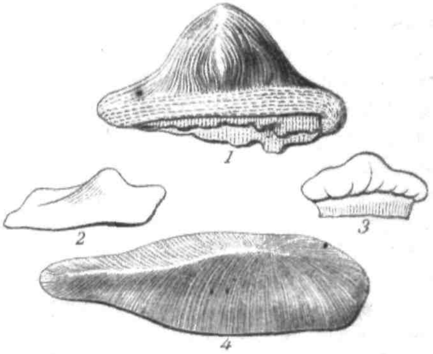
The extinct forms of this family (*Cestracionidæ*) are known almost only by their teeth; and according to the shape, structure, and sculpture of these organs, M. Agassiz has arranged them into several genera. They occur in most of the fossiliferous deposits.

CESTRACION CANALICULATUS.—The teeth of a fish belonging to the existing genus have been discovered in the Chalk of Kent; they are figured and described by Sir P. Egerton in the beautiful work by Mr. Dixon.* This unique specimen consists of a group of thirteen posterior molar and three or four detached prehensile anterior teeth, imbedded in a block of chalk about two inches square. The chief distinction from the teeth of the recent Cestracion is in the presence of a large medullary canal which traverses the base of each tooth: hence the specific name.

ACRODUS (*ridge-tooth*) NOBILIS. *Lign.* 189, *fig.* 4, *Ly.* p. 275, *fig.* 307.—In the Lias and Oolite, oblong enamelled teeth, having the surface of the crown covered with fine radiating grooves and striæ, are well known to collectors, in many parts of England, by the name of *fossil leeches*, from a fancied resemblance to a contracted leech. They belong to an extinct genus of Cestracionts, named *Acrodus* by M. Agassiz. The crown of the tooth is enamelled, and covered with transverse grooves, which diverge from a longitudinal furrow; the base is in the form of a parallelogram inclined on its inner side. These teeth were inserted along the

* Dixon's Fossils of Sussex, &c. p. 365, tab. xxxii. fig. 8. From the examination of a specimen lately found at Lewes, Sir P. Egerton has been led to assign to this species the spine formerly described as *Spinax major.*

jaws in oblique series, their longitudinal direction corresponding with that of the bones which supported them; in their natural position, the extremity of a hinder tooth was enclosed between the two next anterior teeth. A beautiful group is figured *Bd.* ii. pl. xxvii[c].*



LIGN. 189. FOSSIL TEETH OF SHARKS.

Fig. 1.—PTYCHODUS MORTONI. (G. A. M.) *Cret. New Jersey.*
2.—PSAMMODUS CINCTUS. (*Ag.*) *Mt. L. Bristol.*
3.—ORODUS CINCTUS. (*Ag.*) *Mt. L. Bristol.*
4.—ACRODUS NOBILIS. *Lias. Lyme Regis.*

PTYCHODUS (*wrinkle-tooth*). *Pl. VI. fig.* 2; *Lign.* 189, and *Lign.* 191.—The palatal teeth, which occur more or less abundantly in almost every chalk-pit, and are known by the name of "*palates*," belong to several species of the genus *Ptychodus.* A very common form is figured *Pl. VI. fig.* 2: and microscopic views of vertical and transverse sections, as seen by transmitted light, are shown in figs. 2[b], 2[c]. Groups of these teeth, somewhat naturally arranged, and varying in size and form according to the situations they occupied in the jaws, are occasionally found: one specimen in the

* The microscopical structure of the teeth of *Acrodus* is well shown in the "Odontography," pl. xiv. xv., and beautifully illustrates the relation of dentine to bone.

Bone-bed of the Lias; they consist of consolidated plates instead of separate teeth; there was probably but one plate on each side the jaws. The upper margin is generally undulated, and more or less worn by use. These dental plates are composed of two distinct layers; the lowermost portion, or root, is an osseous, reticulated tissue, as in cartilaginous fishes in general; and the upper consists of dentine, with minute parallel vertical tubes, as in Psammodus; these tubes are a continuation of the medullary tissue of the osseous root.

One species occurs in the Great Oolite at Stonesfield, and very many forms abound in the Bone-bed at Aust Cliff, near Westbury on Avon: and in the Trias (bone-bed) of Germany the teeth of several species of Ceratodus are very abundant.

The fishes to which these fossil teeth, referred to *Ceratodus*, belonged were most probably Cestracionts; the ray-spine known as *Nemacanthus* is provisionally assigned to them.

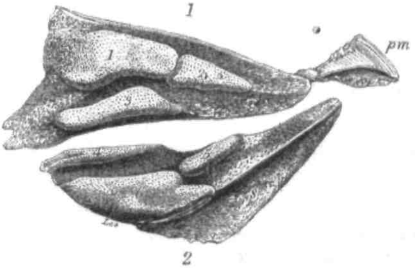
EDAPHODON. *Lign.* 190 and *Lign.* 191, *Ly.* p. 276, *fig.* 309. —The Chimæroid fishes, though formerly placed with the Plagiostomes (Sharks and Rays), constitute a distinct group, of which there are but two recent genera, though several occur in a fossil state. Their dental organs are very peculiar. Their mandibles are furnished with two or more pairs of oblong teeth, composed of long hollow cylindrical columns, placed nearly at right angles to the grinding surface, which is pitted with minute depressions. These teeth are never shed, but are persistent, and grow on through life, as in the Rodentia, exhibiting in this respect a striking contrast with those of the Sharks, which are feeble and numerous, and constantly replaced by rows of successional teeth.

Fossil teeth of several species, some much larger than the recent, have been found in the Tertiary, Cretaceous, and Oolitic deposits. The first British specimen was discovered in the Chalk-marl at Hamsey, in 1820, by myself; but its

nature was not suspected until more perfect examples were obtained from the Kimmeridge Clay at Shotover by Sir P.

LIGN. 190. MANDIBLE OF EDAPHODON MANTELLI.

Chalk. Lewes. (½ *nat. size.*)



LIGN. 191. EDAPHODON LEPTOGNATHUS. ½ *nat.*

London Clay. Bracklesham.

The Upper and Lower Mandibles of the left side; viewed mesially or from within.

Fig. 1.—The Upper Jaw; left ramus.
p m.—The premaxillary bone.
1, 2, 3.—The three dental tubercles.

Fig. 2.—The Lower Jaw.
s.—The symphysial surface, by which this ramus is united to the opposite or right side of the jaw.
4, 5, 6.—The three dental tubercles, or triturating surfaces, of the left ramus of the lower jaw.

Egerton, and were submitted to Dr. Buckland, who subsequently ascertained their characters and relations by an

examination of the dental organs of a recent *Chimæra* in the Museum at Leyden in 1835.*

Many specimens, both of the upper and lower mandibles, have since been discovered in the Eocene beds, Chalk, Upper Greensand, Galt, Kimmeridge Clay, and Stonesfield Slate. The subject has been carefully investigated by Sir P. Egerton: and this eminent Ichthyologist has tabulated the principal forms, and arranged them under five genera.†

In some species the external vertical wall of the plate is formed of hard dentine, resembling enamel; in others the dentine is disposed in isolated ramifications, producing a dendritical appearance; the modifications of this structure occasion the differences observable in the dental plates of the various species. In some, compact dentine with parallel canals constitutes the mass of the tooth; in others, the squamous dentine with ramifying tubes prevails.

I have figured the right upper and lower mandibles of the type named EDAPHODON (*pavement-tooth*), in which there are *three* teeth or dental tubercles on each ramus of both jaws, *Lign.* 191: the lower mandible is produced anteriorly into a falciform beak:‡ the articulating surface of the symphysis (2 *s*) is broad at the base, and contracts gradually forward until the margins meet at the apex. In *Ischyodus* the lower jaw is deeper, less produced in front, and the margins of the symphysis are parallel until abruptly truncated at the extremities: the upper jaw has *four* tubercles on each side.

The upper jaw in ELASMODUS has but three tubercles, as in Edaphodon, but the dentine of which they are composed is confluent, being rolled round like a scroll in the substance

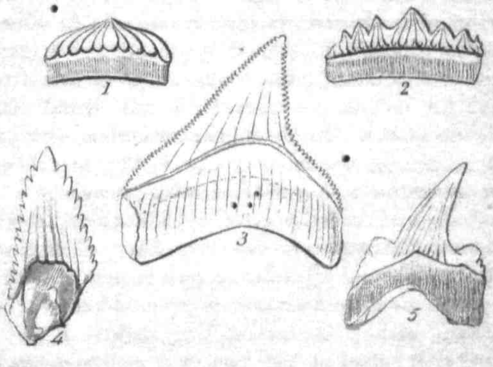
* Proceedings of the Geological Society of London, vol. ii. p. 209.

† Viz. Ganodus, Ischyodus, Edaphodon, Elasmodus, and Psaliodus. See Quart. Journ. Geol. Soc. vol. iii. p. 35; and Dixon's Foss. Sussex.

‡ Hence M. Agassiz proposed the name of *Psittacodon* (parrot-tooth) for this genus of Chimæroids.

of the bone, one edge forming the margin of the tooth, and the other being buried deep in its centre.

The dorsal fin-ray or spine of the Edaphodon is laterally compressed, with the posterior margin grooved, and the edges armed with fine teeth; I have a specimen of the spine, with a pair of inferior mandibles of the same individual, imbedded in a block of chalk from Kent; by favour of Mrs. Smith, of Tunbridge Wells.



LIGN. 192. FOSSIL TEETH OF SHARKS.

Fig. 1.—HYBODUS MEDIUS. *Lias. Lyme Regis.*
2.—HYBODUS RARICOSTATUS. *Lias. Bristol.*
3.—CARCHARODON PRODUCTUS. *Tert. Malta.*
4.—HEMIPRISTIS SERRA (fragment). *Chalk. Ratisbon.*
5.—OTODUS OBLIQUUS. *Tert. Sheppey.*

HYBODUS. *Lign.* 192, *figs.* 1, 2. (*Bd.* pl. xxvii.[d]).—Intermediate between the obtuse crushing teeth of the Sharks previously described, and those sharp, angular, pointed, dental organs of the Squaloids, are those of the fishes which M. Agassiz has arranged in a sub-family or group termed *Hybodonts*; the teeth of which are characterised by their transversely elongated form, and the series of subacute, compressed, conical cusps or points, which compose the crown. The median cone is the principal, the lateral

points being shorter and smaller, as in *Lign.* 192, *fig.* 2; in some species the difference between the median and lateral cones is greater, in others less, as in *fig.* 1. These cusps have a coating of dense enamel, which is plicated longitudinally on both faces. The base, which almost equals the crown in size, is composed of a coarse osseous substance. The internal structure of the crown differs from that of the Cestracionts, in having no principal pulp-cavity, and in being chiefly composed of dendritical dentine, with reticulated medullary canals. The form and organization of these teeth show them to have been instruments for cutting and tearing food. The Hybodonts, as we have already stated (p. 581), possessed two spinous dorsal fins; in their habits and economy they probably did not differ from the ordinary Sharks. Teeth and spines of this genus are common in the Trias, Lias, Oolite, and Wealden, and occur in the Green Sand and Chalk. There are several species of teeth and fins in the strata of Tilgate Forest (*Foss. Til. For.* pl. x.). In general the teeth are found detached, but occasionally they occur in their natural position, adhering to the mineralized cartilaginous jaws (*Petrif. Lign.* 97); as in the beautiful fossil figured *Bd.* pl. xxvii.[d] c; and in the fine specimen of *H. basanus*, from the Isle of Wight, figured in the *Geol. Soc. Journ.* vol. i. pl. iv. There are several related genera, founded on the situation, form, and division of the principal cusps of the teeth.

SHARKS WITH CUTTING TEETH.—The jaws of the common squaloid fishes, as the LAMNA (*Porbeagle*) and CARCHARIAS (*Great White Shark*), are so common in collections of natural history, as to render a description unnecessary. The numerous vertical rows of angular, laterally compressed, pointed teeth, with sharp or serrated edges—in some species consisting of a simple trenchant cusp, in others with small lateral teeth, or denticles, at the base, are characters with which all are familiar. Fossil teeth of this form are extremely

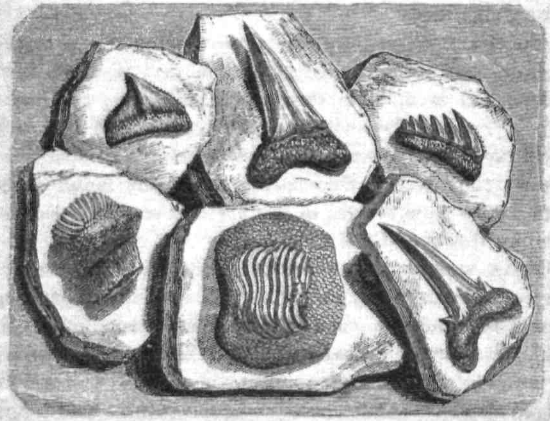
abundant in the Tertiary and Cretaceous deposits; and are commonly in a beautiful state of preservation. The genera of these fossil teeth are founded on the solidity or hollow structure of the cusps, their possessing cutting or serrated edges, and the presence or absence of lateral denticles. But the last character cannot in every instance be relied upon, for some recent Sharks have rows of teeth both with and without denticles.

CARCHARODON PRODUCTUS. *Lign.* 192, *fig.* 3.—The genus *Carcharias* comprises the large Sharks with cutting triangular teeth, crenated (*notched*) on their margins, and having a broad base. In *Carcharodon*, the teeth differ from those of Carcharias in being solid in the centre, while in the latter they are hollow; but in both genera the teeth exhibit the same reticulated structure of medullary and calcigerous tubes. The *White Shark* and other large species belong to these genera; some of which are upwards of forty feet in length. But even these colossal fishes must have been far surpassed in magnitude by the extinct species of the Tertiary deposits, if the teeth afford a scale of proportions; for some of the fossil teeth from Malta and the United States are six inches long, and five wide at the base;* being twice the size of the teeth in the largest living species. The specimen figured in illustration, *Lign.* 192, *fig.* 3, is of a small size.

HEMIPRISTIS SERRA. *Lign.* 192, *fig.* 4.—The fossil teeth of this genus are distinguished by serrated edges, that do not extend to the summit, which is a sharp angular point; as in the fossil represented.

* For instance, some of the Maryland specimens of *Carcharodon megalodon*. See an admirable memoir on the Fossil Squalidæ of the United States, by Dr. R. W. Gibbes, Journ. Acad. Nat. Science, Philadelphia. At the m eting of the British Association in 1851, J. S. Bowerbank, Esq. F.R.S. read some interesting observations on the comparison of these large fossil fishes with the recent *Carcharias glaucus* of Australia. See also Owen, Cyclop. Anat. *Art.* TEETH.

LAMNA ELEGANS. *Lign.* 193, *fig.* 6.—The fishes of the genus *Lamna* (to which the recent shark called the *Porbeagle* belongs) have teeth with smooth trenchant edges, and a small sharp denticle (*little tooth*) on each side the base, as in the fossil, *Lign.* 193, *fig.* 6. The specimen, *fig.* 2, although



LIGN. 193. FOSSIL TEETH OF SHARKS. *Chalk. Lewes.*

Fig. 1.—CORAX PRISTODONTUS.
2.—LAMNA CRASSIDENS.
3.—NOTIDANUS MICRODON.
4.—PTYCHODUS POLYGURUS; seen laterally.
5.—PTYCHODUS POLYGURUS; viewed from above.
6.—LAMNA ELEGANS.

devoid of denticles, probably belongs to the same genus, for reasons already explained. Several species abound in the Chalk; and they are associated with teeth, which are relatively wider and shorter, and have large compressed denticles; the latter are arranged in a separate genus, named OTODUS (*eared-tooth*), by M. Agassiz. The specimen figured

Lign. 192, *fig.* 5, represents *O. obliquus;* another species, *Otodus appendiculatus*, is abundant in the Sussex Chalk. The large, wide, triangular, smooth teeth, with trenchant edges, and destitute of lateral denticles, so common in the Chalk, are related to *Lamna*, and are comprised in the genus *Oxyrhina* (*Poiss. Foss.* tom. v. tab. xxxiii.).

NOTIDANUS MICRODON. *Lign.* 193, *fig.* 3.—These teeth differ remarkably from those of the other genera of Sharks. The crown of each tooth is composed of a series of sharp angular enamelled points, the first of which is the largest, and is notched on its anterior edge; the base or root is osseous, flat, with a slight longitudinal depression below the border of enamel. These teeth are comparatively rare in the Chalk. One species has been found in the Oxford Clay; and several in the Tertiary strata. Specimens occur in Hordwell Cliff.

CORAX PRISTODONTUS. *Lign.* 193, *fig.* 1.—The teeth of the fossil *Corax* chiefly differ from those of the recent genus *Galeus*, to which the *Tope*, or Grey Shark, belongs, in being solid; they are of a triangular form, with a deep concavity or notch on the posterior margin, the base of which is prolonged and forms three or four angular points: the anterior edge of the tooth is finely serrated. The root of the tooth, as in *Notidanus*, is a broad osseous plate. There is much diversity of form in the Chalk specimens, which are all of a small size, as in *Lign.* 193, fig. 1. In Sussex they are more common in the Chalk-marl than in the Chalk.

The only fossil teeth of the Shark family resembling those of the tertiary Carchariodonts, that have been discovered in the strata below the Chalk, are from the carboniferous deposits of Yorkshire and Armagh. These teeth are compressed, triangular, crenated on the edges, with large plaits or folds on the enamelled surface, towards the base of the crown. M. Agassiz refers them to a new genus, viz. CARCHAROPSIS, with the specific name of *Prototypus*.

FOSSIL VERTEBRÆ OF SHARKS.—As the cartilaginous nature of the skeleton in this family renders it unfavourable to preservation in the mineral kingdom, the durable parts already described, and those which are ossified, are almost the only relics found in a fossil state. The dermal integument is, however, sometimes preserved; and I had a beautiful example of shagreen, composed of irregular minute hexagonal scales, one of which is represented highly magnified, *Lign.* 185, *fig.* 1.

In the *Galeus* and *Carcharias* the vertebræ are more ossified than in many other genera of cartilaginous fishes, and fossil vertebræ of these sharks often occur in the cretaceous and other strata. Groups of vertebræ of a large size occasionally occur in the Sussex Chalk; they are circular, biconcave, and very short; one specimen is four inches in diameter, and one inch long; their concavities are consequently shallow. These vertebræ are composed of two shallow conical disks, which are united by their summits, at the axis, and are connected and supported by numerous wedge-shaped plates, that radiate from the centre to the periphery (see *Foss. South D.* pl. xxxiii. fig. 10). My collection contained a connected series of forty small vertebræ from the Chalk near Lewes, which probably belonged to the same species of Shark as the dorsal spine named *Spinax major* (*Poiss. Foss.* tom. iii. pl. xl[a]. fig. 6).

SQUALORAIA.—In the Lias of Lyme Regis, that inexhaustible storehouse of fossil treasures, a considerable portion of the skeleton of a very remarkable fish, partaking of the characters of the Sharks and Rays, was discovered by Miss Mary Anning, and is now in the Museum of the Bristol Institution.* In this fish the jaws are prolonged into a beak, like the Pristis (*Saw-fish*). It has the head of a Shark, with a long beak; vertebræ of the Rays; with pectoral and

* It is figured and described by Dr. Riley, Geol. Trans. 2d ser. vol. v. pl. iv. See also Poiss. Foss. tom. iii. pl. xlii.

ventral fins, almost equally developed; a tail armed with a spine; and spinous bosses, as in the true Rays.

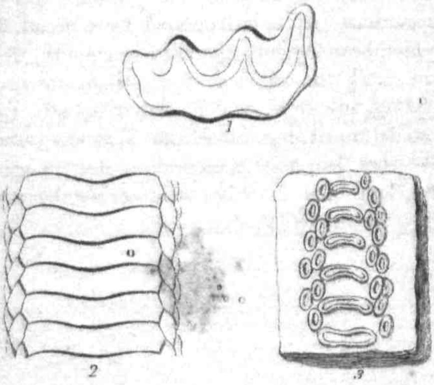
Fossil Pristis, or Saw-fish.—This well-known predatory fish, which is allied to the Rays and Sharks, and referred by M. Agassiz to the family of *Raiidæ*, has projecting from its snout an osseous, flat, horizontal plate, or beak, equal in length to one-third of the fish, and armed on each side by a row of elongated, compressed, pointed teeth, implanted in sockets; the front margin of these teeth is convex, the posterior concave; this defence is termed the saw, and constitutes a most powerful weapon. The *Pristis* has also numerous small obtuse teeth on the jaws. The remains of the beak, or saw, of an extinct species of Pristis have been discovered in the Bagshot Sand at Goldsworth Hill, Surrey;* and three other species have been found in the London clay of the Isle of Sheppey, and the Eocene beds at Bracklesham and Hordwell.†

Fossil Rays.—The teeth of these fishes are characterised by the extraordinary transversal development of the median teeth in both jaws. Instead of pointed teeth, they have wide, flat, tesselated dentary plates in each jaw, composed of distinct pieces, juxtaposed and connected by their margins, and united by fine sutures. In some species the teeth are equal, in others of various sizes; they present numerous modifications of arrangement, and are always disposed in symmetrical rows. In the genus Myliobatis (*Eagle-ray*) the teeth of the median row are of an extraordinary width, while their length does not exceed that of the lateral plates, or chevrons, which are of an irregular hexagonal form, and disposed in two or three rows on each side. There are five living species of *Myliobatis*, and eighteen fossil species have been found in the Tertiary strata at the Isle of Sheppey,

* Proc. Geol. Soc. vol. ii. p. 687.

† Two teeth are figured in Dixon's Fossils of Sussex, pl. xii.; the specimens are in the British Museum; see *Petrifactions*, p. 414.

Hordwell Cliff, and Bracklesham Bay. I have figured a specimen of part of the upper jaw of a species (*M. micropleurus*, *Lign.* 194, *fig.* 2), in which the median teeth are very wide, and have two lateral rows of small, irregularly hexagonal, plates. The surface of the teeth in



LIGN. 194. FOSSIL TEETH OF FISHES

Fig. 1.—CERATODUS EMARGINATUS: $\frac{1}{2}$ *nat.* *Lias Bone-bed.* *Aust Cliff.* A single dental plate.

2.—MYLIOBATIS MICROPLEURUS: $\frac{1}{3}$ *nat.* *Tert.* *Isle of Sheppey.* A series of six median teeth, with the corresponding lateral teeth.

3.—PYCNODUS MANTELLI. *Weald.* *Tilgate Forest.* This specimen consists of the *vomerine* bone, with a median row of flat, arched teeth, and two rows on each side of elliptical teeth, arranged alternately.

this species is smooth; but in others it is striated longitudinally (*Bd.* pl. xxvii^{d}. fig. 14). In an allied genus, ÆTOBATIS, from the Tertiary beds at Bracklesham, the lower jaw projects beyond the upper, and in each there is a row of flat, transverse teeth, *without* lateral plates.

To this notice of the fossil Rays, we may add, that a gigantic TORPEDO has been discovered in that celebrated

locality of Ichthyolites, Monte Bolca; and that Sir Philip Egerton has recently enriched his matchless collection of fossil fishes, by a perfect Ray, from Mount Lebanon. It is figured and described in the *Quarterly Geol. Journ.* vol. i. pl. v. p. 225, under the name of CYCLOBATIS OLIGODACTYLUS. It is a small species, resembling the common Rays in its general appearance, but is surrounded by a broad, flexible, cartilagino-membranous fin; the skin is smooth, the teeth and eyes are small, the tail is slender; there are no traces of dermal spines, tubercles, or defensive weapons. In many points of structure it resembles the Torpedo; and may possibly, like that fish, have possessed an electric organ. It is $3\frac{1}{2}$ inches long, and 3 inches wide across the expanded fins.

CHAPTER XV.

FOSSIL ICHTHYOLOGY; COMPRISING THE GANOID, CTENOID, AND CYCLOID FISHES.

THE fishes we have hitherto examined belong to the first order, the *Placoidians;* we now pass to the fossil remains of the second order, the *Ganoidians*, which are distinguished by their brilliant angular scales, formed of osseous or horny plates, densely covered with enamel. This order contains six or more families, comprising many genera and numerous species; our investigation must be restricted to a selection from the principal genera of the *Ganoids*, properly so called, and of the *Sauroids*, or lizard-like fishes.*

The first family, termed LEPIDOIDES, contains several genera, which are defined as possessing either numerous rows of brush-teeth, or of obtuse conical teeth; flat, rhomboidal scales, arranged parallel with the body; and an osseous, or partially osseous, skeleton. In one division of this family, the body is either elongated or fusiform, the mouth furnished with brush-teeth only, and the tail heterocercal, or unequally bilobed (see p. 576). To this group belong several genera, which are restricted to the Secondary formations more ancient than the Oolite; while the other group, with homocercal tails, lived in the Oolitic and Cretaceous seas. Two genera, in particular, abound in the

* The fishes of these orders are described in *Poiss. Foss.* tom. ii.

Permian and Carboniferous strata; namely, *Amblypterus* and *Palæoniscus*.*

AMBLYPTERUS. *Lign.* 187. *Wond.* p. 740. *Bd.* pl. xxvii.[b]. —The fishes of this genus, as the name indicates, have very large and wide fins, composed of numerous rays. The scales are rhomboidal and finely enamelled; the tail is heterocercal. The figures referred to convey a correct idea of the form and external characters. Beautiful pyritous imprints of Amblypteri occur in the Carboniferous slate of Saarbrück, in Lorraine; and fine specimens in the iron-stone nodules of the same locality. On the shore at New-haven, near Leith, similar fossils occur in nodules washed out of the cliffs of coal-shale (*Bd.* p. 278).

PALÆONISCUS. *Ly.* p. 304.—The fishes of this genus differ from those of Amblypterus in the relatively moderate size of the scales, and the numerous little rays on their margins. They have rhomboidal scales, which in some species are very small, and in others large. They have numerous brush-teeth. Several peculiar species, found in the marl-slates and magnesian limestones of the Permian system, are very widely distributed, occurring in the British Isles, Germany, and the United States.

In some localities the small species occur in groups; on a slab of red sand-stone, in the Museum of the Geological Society, from Tyrone, between two and three hundred perfect fishes (*P. catopterus*) are imbedded on a space not exceeding two feet square.

A remarkable circumstance relating to the fishes of this genus is the almost constant absence of the bodies of the vertebræ in otherwise well-preserved specimens, and in which the spinal processes and the ribs are entire: occasionally, however, examples occur with some of the vertebræ

* For the characters, affinities, and distribution of these and the allied genera of the Heterocerque Ganoid fishes, see Sir P. Egerton's Memoir in the sixth volume of the Quarterly Geological Journal.

perfect. An explanation of the above phenomenon may perhaps be found in the probable originally cartilaginous nature of the bodies of the vertebræ, and the osseous structure of the enduring apophyses and ribs;* while those rare specimens which possess a few bony vertebræ may be regarded as exceptions, in which ossification took place in a structure essentially cartilaginous.

The fishes found in the copper-schists of the Zechstein, at Mansfeld in Saxony, are generally impregnated with copper pyrites, and their scales are as brilliant as burnished gold. These ichthyolites are almost always in contorted and twisted positions; which appearance M. Agassiz attributes to contraction of the muscular tissues after death, during the progress of decomposition, and before the fishes sank down and became imbedded in the mud. (*Poiss. Foss.* tom. ii. p. 70.)

The fishes of the genus Palæoniscus are often found in the shales and marls of the Permian and Carboniferous systems of England and Scotland. At East Thickley, in the county of Durham, numerous specimens have been found.† The lower Carboniferous strata at Burdie-house, a locality we have before mentioned, have yielded several species of Palæoniscus, associated with teeth and other remains of large sauroid fishes.‡ On the continent also they prevail in deposits of the same epoch; Eisleben and Mansfeld, in Saxony, are well-known localities. In North America they have been discovered in strata of probably the same age.§ In fine, the genera Amblypterus and Palæoniscus may be regarded as characteristic "medals" of

* Professor Owen states that a similar condition of the spinal column obtains in the fossil Microdonts.—*Rep. Brit. Assoc.* 1846.

† See Professor Sedgwick on the Magnesian Limestone. Geol. Trans. 2d ser. vol. iii.; and Prof. King's Monograph on the Permian Fossils, published by the Palæontographical Society.

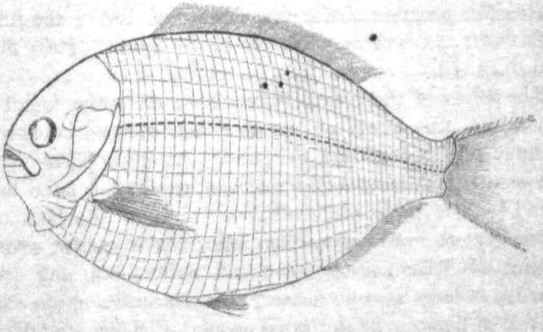
‡ Dr. Hibbert's Memoir on the Fossils of Burdie-house.

§ Geology of Massachusetts, by Professor E. Hitchcock.

the geological epoch which intervened between the Devonian and Triassic formations.

We will next examine a few genera of the homocercal Lepidoids and Pycnodonts, whose relics are chiefly distributed in the Lias, Oolite, Purbeck, and Wealden.

DAPEDIUS. *Lign.* 195.—At Lyme Regis, and other productive localities of the fossils of the Lias, large masses of angular enamelled scales, and occasionally entire specimens of the fishes to which they belonged, have for many years been collected. Sir H. De la Beche first scientifically investigated the structure of these Ichthyolites, and pointed



LIGN. 195. OUTLINE OF THE DAPEDIUS. *Lias.* (½ *nat. size*).

out their characters and relations. The Dapedius (of which a restored figure is given in *Lign.* 195) is a flat, laterally compressed fish, with a rounded head, and fins of moderate size. The body rapidly contracts towards the root of the tail, the fin of which is large and symmetrically lobed. The mouth is furnished with several rows of small conical teeth, which are crenated at their summits, and has brush-teeth on the palatine bones; the jaws are short. The scales are rhomboidal, highly polished, and united laterally

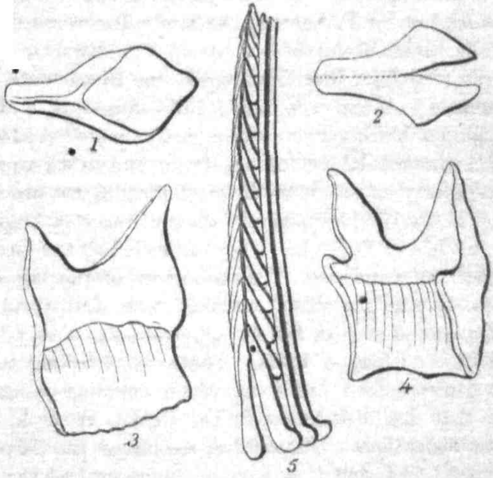
by short processes; as in many other ganoid fishes. It belongs to the Lepidoids.

The TETRAGONOLEPIS is a Liassic fish, very similar in shape to the Dapedius. It was formerly grouped with the *Lepidoidei*, but Sir P. Egerton has lately discovered that it essentially differs from those fishes in the character of its scales and teeth, and that it belongs to the Pycnodonts.

LEPIDOTUS.* *Lign.* 186, 196, 197.—Scales of a dark-brown, almost black colour, with a glossy enamelled surface, and of a rhomboidal or lozenge form, and teeth equally dark and glossy, of an obtuse hemispherical figure, are very common in the Wealden strata of the south-east of England and in the Isle of Purbeck. They are called by the quarry-men *fishes' scales* and *eyes*. The collectors of the last century used to term the obtuse circular teeth of this and the related genera *Bufonites*, from a supposition that they were formed in the heads of toads. These relics belong to an extinct genus named *Lepidotus*, which contains numerous species, that are distributed in the Oolite, Purbeck, and Wealden formations. These fishes resembled the Carps in their general form, but they have no anatomical relations to that family. The body is covered with large rhomboidal scales, which are protected on the external surface by a thick plate of enamel (*Lign* 196, *fig.* 3). The lateral line, which is slightly arched, passes direct from the operculum to the middle of the insertion of the caudal fin. The head, and even the face, are cased with osseous and enamelled plates. The bones of the surface of the skull are very large, and are connected by sinuous sutures. The jaws are short and rounded, and furnished with a row of obtuse, conical, circular teeth (see *Lign.* 197), and several rows of sessile teeth, more or less contracted at the base, which forms a very short pedicle that is anchylosed to the bone. The fossil Lepidoti are found, for the most part, in fluviatile

* Poiss. Foss. tom. ii. p. 233.

deposits, as in the Purbeck and Wealden strata; and it is probable they inhabited the rivers or sea-coasts, and not deep waters.

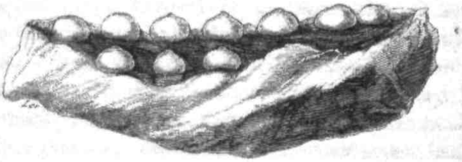


LIGN. 196. SCALES AND FIN OF LEPIDOTUS MANTELLI. *Wealden. Tilgate Forest.* (*Nat. size.*)

Fig. 1.—Scale, with a single process of attachment.
2.—One of the scales of the dorsal line.
3.—Scale (external surface), with a bifurcating process of attachment; the enamelled portion (which alone is visible when the scales are in their natural position on the animal) has longitudinal grooves or folds.
4.—Scale (viewed on the inner surface), having a bifurcating process of attachment and a tooth or projection on each side, to connect the scale laterally with the adjoining scales.
5.—The front ray of the dorsal fin, covered with two rows of enamelled scales, and another ray behind it.

The scales and teeth figured *Lign.* 196, 197, belong to the larger species of the Wealden. The remains of this fish were first collected in Tilgate Forest, and several teeth and scales are figured *Foss. Til. For.* pl. v. and x.; considerable

portions of connected scales have since been found; also the head entire, and the fins more or less perfect. A specimen in my collection retained a mass of the scales near the insertion of the tail, a foot wide; indicating the original to



LIGN. 197. PORTION OF THE JAW OF LEPIDOTUS. *Wealden. Tilgate Forest.* (*Nat. size.*)

This specimen shows three successional teeth beneath a row of teeth in use.

have been twelve feet long, and its body three feet broad. The scales are distinguished from other species by the folds or grooves on their enamelled surface; and the teeth by the contracted base, or pedicle, which is a little narrower than the crown (*Lign.* 197, and *Pl. VI. fig.* 10). A species (*L. Fittoni*) closely related to the above is equally abundant in the Weald of Sussex; the scales are not striated, and the teeth have no pedicle.

The intimate structure of the teeth of the Lepidotus is beautifully preserved, and may be easily examined in thin transverse and vertical sections, viewed by transmitted light: see *Pl. VI. fig.* 10. The dentine is composed of bundles of tubes, continued from the cells of the osseous base, radiating in a vertical direction to the surface of the tooth, as seen in *Pl. VI. fig.* 10, and giving off branches at an acute angle; but when more highly magnified, the finer branches are seen to be spread out and arched at their extremities, "presenting the appearance of the stems of corn, beaten down by heavy rain." *

* Odontography, p. 70. See the beautiful representation of this structure, pl. xxxi.

The dorsal and pectoral fins of these fishes are very strong, and consist of several bony rays. There is a double row of acuminated enamelled scales, arranged more or less obliquely, on the anterior margin of the dorsal and anal fins, and on both margins of the caudal: part of the first ray of a dorsal fin, with scales, is represented *Lign.* 196, *fig.* 5.

A small species of Lepidotus (*L. minor*) is common in the Purbeck limestone, and specimens may often be procured from the quarries near Swanage;* it has also been found at Hildesheim, in Saxony, by M. Roemer. The detached scales abound in the limestones; and the splendid fossil reptile from Swanage, figured *Petrif. Lign.* 38, is sprinkled with the scales and minute teeth of this fish.

The majority of the species of Lepidotus belong to the Lower Oolites and the Lias. The habits of the Lepidoti, as indicated by the form and structure of the teeth, were those of fishes whose food consisted of crustaceans, shelly mollusca, &c.; for the dental organs are peculiarly adapted for the crushing and grinding of such substances; and the teeth of the adult fishes are generally worn down by use.

PYCNODUS. *Pl. I. fig.* 3; *Lign.* 194, *fig.* 3.—The fishes of the family of Pycnodonts, so named from the thickness of their teeth, have an osseous skeleton, a flat body covered with rhomboidal scales, and flat or rounded teeth disposed in several rows on the palatine, vomerine, intermaxillary, and premandibular bones.† As in the Lepidotus, these teeth are constructed for crushing, and have generally a smooth, dense, convex or flattened crown, with a highly polished surface. This genus belongs chiefly to the Oolite:

* Fine specimens of this fish are in the British Museum (*Petrifactions*, p. 429), and in the Museum at Dorchester.

† The *intermaxillary*, *palatine*, and *vomerine* bones compose the vault or roof of the mouth; the vomer occupying the middle; the intermaxillary the front; and the palatine bones the sides; the *premandibular* bones belong to the lower border of the mouth.

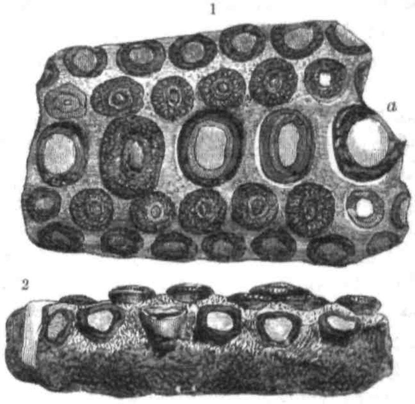
it is found also in the Lias, Chalk, and Wealden. A perfect fish of the genus PYCNODUS (*P. rhombus*), from the Jura limestone, at Torre d'Orlando, near Castellamare, is figured in the frontispiece of the first volume of this work; and a *vomerine* bone, with teeth, from Tilgate Forest, in *Lign.* 194, *fig.* 3. In the last fossil there is a median row of flat, elongated, transversely arched, smooth, glossy teeth, with a double alternate row of small sub-circular teeth on each side, attached to the bone, which is imbedded in Tilgate grit. Specimens of this kind, belonging to one or more species of Pycnodus, occur in the Wealden of Sussex: they were among my earliest discoveries in Tilgate Forest (*Foss. Til. For.* pl. xvii. figs. 26, 27). Examples are met with in which all the teeth are shed, and the bony plate of the vomer alone remains.

GYRODUS. *Lign.* 198.—In another genus of the *Pycnodonts*, termed GYRODUS, the crowns of the teeth are deeply furrowed, the structure of the dentine is very dense, and the pulp-cavity large and simple. One species occurs in the Speeton clay of Yorkshire, and another in the Sussex weald; but the teeth are chiefly found in the Oolite and Chalk. As in Pycnodus, the teeth are distributed in rows on the bones composing the roof, floor, and sides of the mouth.*

These characters are beautifully displayed in the Russian specimen, *Lign.* 198. This interesting fossil was presented to me by the late Stephen Cattley, jun. Esq., who collected it in 1839, in a valley near RJEFF, a village on the banks of the Volga. Mr. Cattley informed me "that many fossils are found in that and the neighbouring valleys; and the locality is frequented by Russian geologists when the season permits, which is but seldom, owing to the long duration of the snow, and the heavy rains which accompany the thaw." This specimen consists of the vomerine bone, which is of a

* An extraordinarily perfect lower jaw of a *Gyrodus* is to be seen in the British Museum (*Foss. Brit. Mus.* p. 439).

coarse texture, and five rows of teeth; the median row consists of very large elliptical teeth; those of the lateral



LIGN. 198. GYRODUS MURCHISONI * (G. A. M.) *Oolite? Russia.*

(Collected by the late Stephen Cattley, jun. Esq.)

Fig. 1.—The vomerine bone of a fish, with five rows of teeth; seen *from above; many of the crowns of the teeth are worn away* by use, and the large pulp-cavities, filled with white spar, are exposed; as at *a*.

2.—Lateral view of the same.

a. One of the pulp-cavities filled with spar.

rows are much smaller and arranged alternately. The peculiar structure of the teeth of this genus † is finely displayed in this fossil. The ample, deep, and simple pulp-cavity is seen in several teeth, where the crown of dentine has been worn off, filled with a pure white calcareous spar; one of these cavities is marked *a*. The dentine is extremely dense,

* It is with peculiar pleasure that I inscribe this new species of *Gyrodus* to Sir R. I. Murchison, in commemoration of those extended and successful geological researches in the Russian empire, which have conferred additional honour on his distinguished name.

† Odontography, p. 72.

consisting of very minute calcigerous tubes, and passes into an external layer of enamel.

The fishes of the genus *Gyrodus* have the body large, flat, and elevated ; the dorsal and anal fins are very long ; and the tail is forked, with equal elongated lobes. The scales are laterally connected by strong processes, as in Lepidotus.

Other genera related to the foregoing occur in the Oölite ; as for example, MICRODON, thus named from the smallness of its very numerous flat angular teeth, arranged in many rows ; PLACODUS, in which the teeth are few, flat, and of great size ;* and PLATYSOMUS (*flat-body*), with orbicular, clavate, teeth.

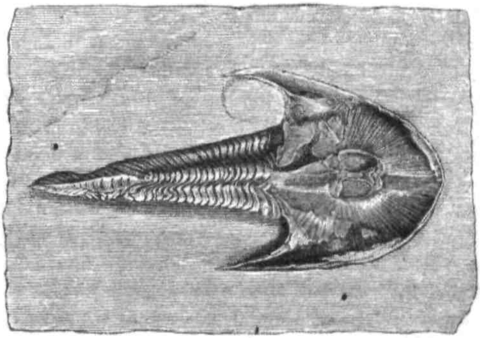
In these fishes, also, the dental organs are well adapted for the comminution of shell-fish, and other hard bodies.

CEPHALASPIDES OF THE DEVONIAN SYSTEM.—The remains of the three genera of Ganoid fishes that we have now to notice are of a very remarkable character, and are found exclusively in the Devonian or Old Red system ; most frequently in Scotland, but also in other parts of the British Isles, and in Europe and America. These fishes agree in one general character, that of having extensive osseous plates, or scutcheons ; their general aspect will be understood by reference to *Lign.* 199, 200, 201. There are no vestiges of the bodies of the vertebræ, which, therefore, were probably cartilaginous. These fishes constitute a distinct family with the name *Cephalaspides*, from the character of the first genus we propose to describe.

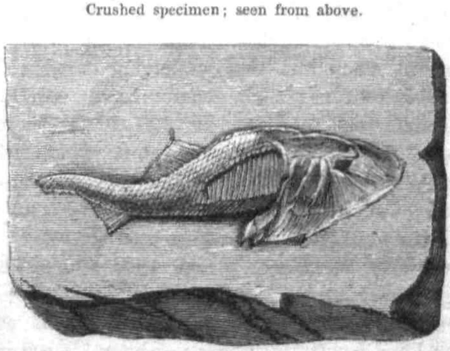
CEPHALASPIS LYELLII. *Lign.* 199, 200.—The most striking feature in the Ichthyolites of this genus is the enormous scutcheon, or buckler, which forms the head, and is prolonged posteriorly into two lateral horns or points ; this part so closely resembles the cephalic shield of certain trilobites (see *Lign.* 175), that the first found specimens were supposed to be the remains of unknown crustaceans,

* Odontography, pl. xliii. fig. 1, and pl. xxx. fig. 2.

The name *Cephalaspis* (*buckler-head*) is derived from this character. This remarkable appearance is occasioned by the intimate anchylosis of all the bones of the cranium.



LIGN. 199. CEPHALASPIS LYELLII. (½ *nat. size.*)
Devonian. Forfarshire.
Crushed specimen; seen from above.



LIGN. 200. CEPHALASPIS LYELLII. (½ *nat. size.*)
Devonian. Glammis, Forfarshire.
Lateral view, showing the produced dorsal lobe of the tail.

The body of these fishes is relatively smaller than the head; it has one dorsal fin, and terminates in a tapering tail, sup-

porting a fin. There are two small eyes, placed towards the middle of the head. The body is covered with rhomboidal scales; and the head with discoidal scales, which are highly ornamented with radiated markings * (*Ly.* p. 344, *fig.* 396). There are four species of Cephalaspis at present known.

The other genera are equally unlike any recent types of the class of fishes. No perfect examples have been found, and some parts of their structure are still unknown; the annexed figures, *Lign.* 201, have been drawn by Mr. Dinkel (the eminent artist employed by M. Agassiz), with scrupulous accuracy, no part being introduced which is not clearly demonstrated in some one specimen; and the form of the scutcheons is made out very distinctly, to aid the collector in discriminating the detached plates, which are the most common relics of these singular beings.

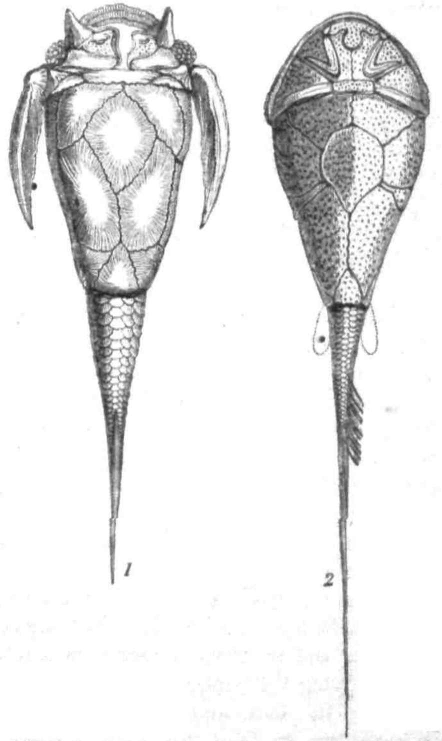
PTERICHTHYS CORNUTUS.† *Lign.* 201, *fig.* 1.—This fish is distinguished by its two wing-like lateral appendages; whence the name of the genus (*winged-fish*). These processes, like the spines on the gill-covers of the common Bull-head (*Cottus gobio*), are weapons of defence. In some specimens they are extended at right angles to the body (*Ly.* p. 345, *fig.* 400).

The head and anterior part of the body are covered with large angular tuberculated scutcheons. The under surface of the body is flat and protected by five plates, a quadrangular plate occupying the centre. The upper part of the body is convex; the form and disposition of the dorsal scutcheons are shown in *Lign.* 201, *fig.* 1. There are two

* Poiss. Foss. tom. ii. p. 135.

† The first fish of this genus was discovered by Mr. Hugh Miller, in whose charming little work, "The Old Red Sandstone; or, New Walks in an Old Field," will be found a very graphic description of the Old Red fishes; I know not a more fascinating volume on any branch of British geology. Consult also Sir P. Egerton's elaborate paper on the *Pterichthys* in the Geol. Journal, vol. iv. p. 302.

eyes, which are placed in front of the lateral spines: see *fig.* 1. The tail is of an angular form, and as long as



LIGN. 201. FOSSIL FISHES OF THE DEVONIAN SYSTEM.
(*Drawn by Mr. Joseph Dinkel.*)
Fig. 1.—PTERICHTHYS CORNUTUS, seen from above.
2.—COCCOSTEUS OBLONGUS.
These figures are restored with great care, from the best preserved specimens hitherto discovered.

the body; it is covered with scales, and considered by M. Agassiz to have been the only instrument of locomotion.

The British species of this genus, of which ten are known, are all very small, varying in length from one to ten inches.

COCCOSTEUS OBLONGUS. *Lign* 201, *fig*. 2.—The fishes of this genus, as may be seen by the lignograph, very much resemble those of Pterichthys; in both the osseous scutcheons of the body are very similarly disposed. In *Coccosteus*, the head* is somewhat rounded; slight rounded notches on the edge of the buckler indicate the place of the eyes on the sides of the head. There is no indication of lateral spines. The tail is very long, covered with scales, and supports a fin. The plates of the body are tuberculated, as in Pterichthys. There are six or eight teeth on each half of the lower jaw (and probably as many on the upper), with a curious group of teeth situated on its symphisis. The teeth are chiefly composed of bone, passing into dentine at their surface.†

These fishes are from a few inches to two feet in length; six species have been discovered; and their remains are the most abundant of the Ichthyolites of the Old Red. Patches of detached scales, and isolated osseous plates, are very frequent in the sandy cornstones, and the subcrystalline masses of limestone. These fragments are usually of a brilliant blue or purple colour; and, strongly contrasting with the dull red tint of the surrounding rock, are easily recognised. The colour is supposed to be due to the presence of phosphate of iron, which has communicated a similar tint to the Ichthyolites of the Caithness Schist.‡

* This is of course only the cranial buckler of the animal, for, as Mr. Hugh Miller observes, "of the true internal skull there remains not a vestige. Like that of the Sturgeon, it must have been a perishable cartilaginous box."—*Miller's Footprints*, p. 50.

† Miller, Rep. Brit. Assoc. 1850. Transact. Sect. p. 92. In the Annals of Natural History for November, 1848, Professor M'Coy has given a corrected outline of the carapace, or bony cephalo-thoracic casing, of the Coccosteus. See also Miller's Footprints, fig. 11.

‡ Murch. Sil. Syst. p. 588; see also a detailed description of the Cephalaspis, Holoptychius, and other Devonian Ichthyolites, by M. Agassiz, ibid. p. 589—601.

Fossil Sauroid Fishes. (*Poiss. Foss.* tom. ii.).—The family of Ganoid fishes termed *Sauroid*, or lizard-like, by M. Agassiz, are so named in consequence of certain peculiarities in their organization which are found in no other animals of this class, but exist in reptiles. There are but two living genera; namely, the *Lepidosteus*, of which there are many species that inhabit the rivers of America; and the *Polypterus*, that contains two species, one inhabiting the Nile, and the other the rivers of Senegal. In these fishes the bones of the skull are closely connected by sutures; the teeth are large, conical, and longitudinally striated, as in the crocodile, plesiosaurus, &c.; the spinous processes are united to the bodies of the vertebræ by suture, as in most reptiles; and the ribs are articulated to the extremities of the transverse processes; the skeleton is osseous. Even in the soft parts many analogies to reptilian structure are seen; thus the Lepidosteus has a glottis, as in the *Siren*; and a cellular air-bladder, with a tracheal vessel, resembling the lungs of an Ophidian (*serpent*). These fishes are the only living representatives of those voracious tribes of the most ancient marine fauna, whose remains abound in the Secondary formations. Their relics have often been mistaken for those of reptiles; particularly the teeth, which from their large size, conical figure, enamelled and striated surface, and internal cavity, were generally supposed to belong to crocodiles. The scales are flat, rhomboidal, and parallel to the body. The recent *Lepidosteus osseus*, of North America, affords a good illustration of the fossil genera; a reduced figure of this fish, from *Poiss. Foss.*, will be found in *Bd.* pl. xxvii[a].; and teeth of some fossil Sauroids are represented *Bd.* pl. xxvii.

The teeth of the Sauroids consist of two kinds; namely, large pointed striated cones, and numerous small brush-teeth. The intricate structure of the conical teeth of the *Stony-gar*, or Lepidosteus, is very remarkable, and presents

some analogy to that observable in the dental organs of the Labyrinthodon, an extinct genus of reptiles, of which we shall treat in a subsequent chapter. The tooth consists of a large conical pulp-cavity, surrounded by a mass of dentine, which is plicated longitudinally, its folds giving to the pulp-cavity an appearance of being divided into parallel longitudinal branches; resembling, in this respect, the base of the tooth of Ichthyosaurus, as shown in a transverse section, *Pl. VI. fig.* 9. If we imagine these folds to be multiplied, and to have more inflections, and the pulp-cavity to be reduced in its proportions, we shall have the elegant organization of the teeth of the *Labyrinthodonts* (see *Pl. VI. fig.* 3^b). The dentine is composed of very minute calcigerous tubes, which pass off at right angles from the pulp-cavity to the periphery; and it is covered by a layer of cement, or coarser dentine, which is encased in a coat of enamel, forming the external investment of the tooth.* The long conical teeth are implanted in *alveoli* or sockets, to the walls of which they are anchylosed at their base.

LEPIDOSTEI.—This family, having the above-described recent *Lepidosteus* for its type, comprises several genera, and is represented in all the formations from the Tertiary to the Coal-measures inclusive. The *Lepidosteus* itself has left its remains in the Eocene tertiary of England. The *Lepidotus* (before described, p. 604,) ranges from the Chalk to the Lias; the *Pholidophorus* and *Dapedius* (p. 603) abound in the Lias; the latter being found also in the Wealden, and the former in the Oolite and Purbeck; and the *Palæoniscus* (see p. 601) is a well-known Permian and Carboniferous form.

* These remarks are based on M. Agassiz's description and my own obsevations. An interesting paper, "On the Microscopic Structure of the Teeth of the *Lepidostei*, and their analogy with those of the *Labyrinthodonts*, with a plate," by *Dr. Jeffries Wyman*, will be found in Amer. Journ. of Science, October, 1843, p. 359.

SAUROIDEI.—The remains of the Sauroids proper occur in the Chalk, Purbeck, Oolite, Lias, Permian, and Carboniferous rocks. The great strength and size of some of these teeth prove that the seas of those remote periods were inhabited by voracious fishes of enormous magnitude. See *Petrif.* pp. 432, *et seq.*

The teeth and jaw of a gigantic sauroid (*Megalichthys*), from the Carboniferous strata at Burdie-house, are figured *Bd.* pl. xxvii.; the sections of the teeth shown in figs. 13, 14, of that plate, illustrate the size of the pulp-cavity and the thickness of the layer of dentine. These remains were associated with the plants and crustaceans previously described; an assemblage of fossils indicating a lacustrine or estuary formation. Similar teeth have been found in the cannel-coal of Fifeshire.

In the Upper Lias of Ilminster, Somerset, the nodular calcareous rock is rich with the remains of the *Pachycormus*, many fine specimens of which Mr. C. Moore, of that town, has successfully worked out from their stony encasement, exhibiting the gaping, contorted fish, as it died in the convulsive throes of suffocation in the muddy sea. The little sauroid *Leptolepis*, of the Lias and the Purbeck, is also abundant in the above-mentioned locality.

In the lithographic stone of Solenhofen, and in the Purbeck strata, Oxford Clay, and Lias of England, occur specimens of a sauroid fish remarkable for the extreme shortness of the lower jaw, and the prolongation of the upper into a beak; it is named *Aspidorhynchus* by Agassiz. The figure of this fossil fish is contrasted on pl. xxvii[a]. *Bd.* with that of its recent ally, the *Lepidosteus.*

In the Shanklin sand and in the Galt of Kent and Sussex, large, conical, striated teeth belonging to sauroid fishes are occasionally found. They invariably occur detached, and no portion of the jaws has been observed. In the Chalk of Sussex several fine sauroid fishes have been

discovered; such as the *Lophiostomus*,* *Belonostomus*,† and *Caturus*; the last two of which are found in the Oolite and Lias also. These have been described and figured in the late Mr. Dixon's "Geology and Fossils of Sussex."

The SAUROIDEI-DIPTERINI‡ are found almost exclusively in the Devonian formation. *Osteolepis*, *Diplopterus*, and *Dipterus* are characteristic members of this family. Interesting descriptions and instructive figures of the structure of these genera are given in Mr. Hugh Miller's late work, "Footprints of the Creator, or the Asterolepis of Stromness," at pp. 50 to 61.

CŒLACANTHI.—This is a numerous family of sauroid fishes, that have derived their name, *hollow-spine*, from the central cavity in the fin-rays, which, however, may have had originally cartilaginous cores. They are found from the Devonian to the Cretaceous series. In the former, one of the most remarkable is the genus *Holoptychius*, distinguished by the peculiar structure of the scales; the enamelled surface of which is covered by undulated furrows. The whole body is covered by thick enamelled scales of this kind. A splendid specimen, twenty-eight inches long, and twelve wide, is figured *Murch. Sil. Syst.* pl. ii.*bis.* Scales have been found exceeding three inches in length, by two and a half in width; which must have belonged to a fish of great magnitude. *Ly.* fig. 395.

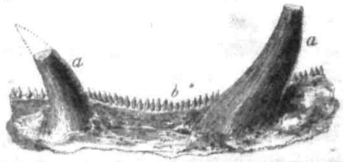
In the Old Red sand-stone of Elgin, at a quarry at Scat-cray, some peculiar teeth occur, which possess a very remarkable structure, and have been referred to a genus of sauroid fishes, which, from the dendritical or arborescent disposition of the calcigerous tubes, Prof. Owen has named *Dendrodus*. These teeth are of a conical form, slightly curved,

* *Geol. Surv.* Dec. 6. pl. x. xi. † *Petrif.* p. 431.

‡ The characters of the scales of this and the next family, as well as of the Acanthodei, are succinctly given in Miller's Footprints of the Creator, pp. 30, *et seq.*

and solid throughout. On the external surface they are finely striated longitudinally, and have two opposite vertical ridges; the base is rough, and its margin rounded, as if for attachment to a shallow socket. The largest specimen is one and a half inch in length. In thin sections, viewed microscopically by transmitted light, there is a central pulp-cavity, of small size; the medullary canals pass into a few short ramifications, like the branches of a shrub, and these are distributed into irregular dilatations, simulating leaves, which resolve themselves into radiating bundles of calcigerous tubes; a portion of a transverse section * is shown *Pl. VI. fig.* 8.

In Mr. H. Miller's charming work just referred to we have a full and clear account of the singular fossil fish the ASTEROLEPIS. Remains of this gigantic Ganoid were first found in Russia.† Its name is derived from the stellate markings on the dermal plates of the head, which are of great size, and form a strong expanded buckler, the orbits of the eyes being situated near the anterior border. (See Miller's *Asterolepis*, pp. 74, *et seq.* figs. 27—29. *Lign.* 202



LIGN. 202. ASTEROLEPIS. *Devonian.* (½ *nat. size*)
Inner side of portion of the lower jaw.
(*After Miller.*)

shows a part of the lower jaw of this fish, seen on the inside. Along the upper margin are seen a "thickly set row of

* Odontography, pl. lxii. B fig. 2; and Cycl. Anat. *Art.* TEETH.

† Casts of the fossil bones from Russia are in the British Museum; *Petrif.* p. 435.

small broadly-based teeth,"—these are ordinary *fish*-teeth; and behind this edge-row of small teeth, *b*, there occur "a thinly set row of huge *reptile*-teeth, based on an interior platform of bone, which formed the top of the cartilage enclosing box composing the jaw." (*Miller.*) These large teeth, *a a*, are longitudinally striated, and generally bear two sharp lateral cutting edges.*

MACROPOMA MANTELLI. *Wond.* p. 348. (*Foss. South D.* tab. xxxvii. xxxviii.; *Petrif.* p. 436, *Lign.* 89.)—This Cœlacanth fish is from one to two feet in length, of an elongated fusiform shape, with a large head and two dorsal fins; the anterior fin is imbedded, and has seven or eight strong spinous rays, the first two of which have numerous spines. The opercula are very long and large (hence its name); the scales† are garnished with adpressed spines, disposed in semicircular rows (see *Lign.* 185, *fig.* 2). The teeth are small, conical, and numerous.

Several specimens of this fish are almost perfect. The bones of the cranium, the jaws, teeth, opercula, branchial rays, palatine arches, the surface of the body covered with scales, all the fins, the pelvic bones, the vertebræ and their apophyses, all remain.

In one example, the *vomer*, covered with minute teeth, is exposed. But the most extraordinary fact relating to these Ichthyolites, is the preservation, in every specimen, of the *air-bladder*;‡ even its membranes remain, and separate in flakes; and the ramification of the minute vessels is visible under a high magnifying power. In some instances this bladder is displaced and much distended; but in general it occupies its natural position, and retains

* The microscopic structure of both kinds of teeth is elegantly figured in Mr. Miller's work, pp. 81, 82.

† See Prof. Williamson's Memoir, Philos. Trans. 1849, p. 435; pl. xliii. figs. 27, 28.

‡ See Williamson, *op. cit.* pp. 462—465, and figs. 29, 30.

its elongated, sub-cylindrical form, with a few annular constrictions or folds.

COPROLITES. *Lign.* 139, *figs.* 1, 2.—In more than one example the solid earthy residue of digestion, in small lumps or pellets, of a conical form and spirally convoluted, lies in the abdomen of these fossil fishes. Fossil excrementitious substances of this kind are termed *Coprolites* (*Bd.* p. 198, pl. xv.) ; they occur in many deposits, and belong not only to fishes, but to large reptiles and other animals. *Lign.* 139, p. 432, *fig.* 1, represents the coprolite of a *Macropoma ;* and *fig.* 2, that of a species of *Shark*, from Hamsey. The convoluted appearance of these bodies arises from the peculiar organization of the intestinal canal of the original fishes, in which, as in the recent Dog-fish, a portion of the intestine was spirally twisted, the tube forming several gyrations ; and the passage of the calcareous substance through this constricted canal gave rise to the structure observable in the coprolites. In the Macropoma the gyrations appear to have been few; seldom more than five or six turns being apparent. In the fossil Sharks the convolutions are more numerous, ten or twelve occurring in the length of an inch. In many of the coprolites, the impression of the mucous or lining membrane of the intestinal canal may be detected. Some of the coprolites of the Macropoma are not convoluted ; probably from having occupied the upper part of the digestive tube, and therefore not having been moulded in the spiral part. (See *Geol. S. E.* p. 145. *Foss. South D.* tab. ix.) Minute scales and bones of fishes are occasionally imbedded in the substance of the coprolites, affording evidence of the carnivorous habits of the Macropoma.

COLOLITES. *Bd.* pl. xv[a].—It will be convenient to notice in this place those curious fossils which occur in detached masses in the limestone of Solenhofen, and used to be known to collectors by the term *lumbricaria*, from the

supposition that they were petrified earth-worms. An excellent representation of a fine specimen is given by Dr. Buckland in the plate referred to above. These convoluted bodies M. Agassiz, with his wonted sagacity, has ascertained to be the intestines of fishes; and has therefore named them *Cololites*. Although generally found isolated, specimens occur in which they are imbedded, like the coprolites of the Macropoma, in the abdominal region of fishes. The frequent occurrence of the *Cololites* apart from the body, is explained by the usual process of decomposition in fishes. M. Agassiz remarks that dead fish always float on the surface of the water with the belly uppermost, until the abdomen bursts from distention. The small intestines are then expelled by the evolved gases through the aperture, and soon become detached from the body. I have observed indistinct traces of similar remains in the beds of chalk in which fossil fishes most prevail. Dr. Buckland mentions the discovery, by Lord Greenock, of a mass of petrified intestines distended with coprolite, and surrounded by the scales of a fish, in a block of coal-shale from the neighbourhood of Edinburgh (*Bd.* p. 199).

DERCETIS ELONGATUS. *Wond.* p. 349.—Before proceeding to the investigation of examples of the next order, I will describe a highly interesting Ichthyolite, which in a mutilated state is extremely common in some of the chalk strata of the South-east of England; it is noticed in *Foss. South D.* p. 232. This fish is placed by M. Agassiz in his family of ganoidians, termed *Scleroderms*; and he mentions that another species has been found in the chalk of Westphalia. The *Dercetis* has a very elongated body, with a short head terminating in a pointed beak; the upper jaw is a little longer than the lower, and both jaws are armed with long, conical, elevated teeth, and several rows of very small ones. On each side of the fish there are three rows of osseous

scutcheons like those of the Sturgeon (see *Wond.* p. 349); the body was also covered with numerous small scales. From the form of the body somewhat resembling that of the eel, being very long, and subcylindrical in uncompressed examples, the specimens are generally called "*petrified eels*" by the quarry-men. The examples usually found consist of the elongated body, more or less compressed, and irregularly covered with patches of scales confusedly intermingled; among which traces of the scutcheons may sometimes be distinguished. These specimens occasionally exceed two feet in length, by one or two inches in breadth; with neither extremity perfect, and without any vestige of the fins.* The example figured *Wond. Lign.* 74, is the only instance in which I have seen the cranium perfect. The scutcheons in the Westphalian species have a prominent longitudinal ridge or keel, and their surface finely granulated; they are so large that the whole body of the fish is covered with them.

FOSSIL CTENOID FISHES (*Poiss. Foss.* tom. iv.).—The fishes of this order have imbricated laminated scales, the posterior margins of which are round and finely pectinated; *i. e.* divided into little teeth, like a comb. These scales are nearly circular, but more or less elongated; and, as the laminæ of which they are composed successively diminish from the lowermost to the uppermost, the pectinated margin of each being apparent, the surface is very scabrous; the front edge is sinuous. The common PERCH is the type of the Ctenoidians. The teeth of these fishes are invariably small, and either villous or brush-like.

From the numerous fossil genera I select, in illustration of the characters of this order, the *Beryx*; of which four species occur in the English Chalk, and three others in the Chalk of Bohemia and Westphalia. Of this genus, which is closely related to the Perch (*Perca*), two living species

* See *Foss. South D.* pl. xl. fig. 2, and pl. xxxiv. figs. 10 and 11.

inhabit the seas of Australia. The bones of the skull have dentated crests; the dorsal fin has spinous rays in front, which are united to the soft rays; the margin of the caudal fin has little spinous rays.

The Beryx is one of the most ancient representatives of the Perch tribe, and of the Ctenoid order.

BERYX LEWESIENSIS.* *Wond.* p. 351; *Petrif. Lign.* 90. —This is one of the most common of the Ichthyolites of the Chalk of the South-east of England; it is called "*Johnny Dory*" by the quarry-men; the specimens are from six to twelve inches long. It occurs also in the Chalk of Westphalia. The outline of the perfect form of this species, *Wond.* p. 351, by Mr. Dinkel, conveys an accurate idea of its external characters. It has one dorsal fin, with several spinous rays in front of the soft ray. The head is very large, and the opercular pieces are ornamented with sculptured rays; the margins of the jaws are covered with a broad band of brush-teeth. The orbit is large, and often contains the capsule (*sclerotica*) of the eye. The rays of the gills are short and thick, five are preserved in some examples. The scales are very large; about twenty-five in the median row; their posterior margins have several concentric rows of spines (see *Lign.* 185, *fig.* 3, p. 567). The lateral line is often distinctly apparent, in the form of a tube, contracted behind and expanded in the centre of the scale. The vertebral column is composed of large short vertebræ, with very long apophyses; the ribs are slight.

BERYX SUPERBUS.—This is a larger species, sometimes thirteen inches long, with very large and broad scales. It

* The fossil discovered by me, and figured in *Foss. South D.* tab. xxxvi. was the first perfect fish obtained from the Chalk. This fish was first described by me, *Foss. South D.* tab. xxxv. xxxvi. as ZEUS *Lewesiensis*; M. Agassiz has very properly referred it to the genus *Beryx*; but he has also substituted another specific name; which is wholly unwarrantable, for that first imposed ought to be retained; see p. 518, note.

has been found in the lower chalk at Lewes. See Dixon's *Foss. Sussex*, tab. xxxvi. fig. 5.

Beryx radians. *Wond.* p. 350.—This species is smaller, and relatively longer, than *B. Lewesiensis*; it generally occurs in the Chalk-marl, and is invariably of a very dark colour, the scales having a polished or glossy aspect. The scales are small, with a simple row of diverging spines on the posterior edge. The scales of the lateral line are peculiar; the mucous canal is not formed of a series of simple tubular cylinders, as in *B. Lewesiensis*, but is divided into several branches, as may be seen with a lens of moderate power. There are more than thirty scales in the length of the lateral line.

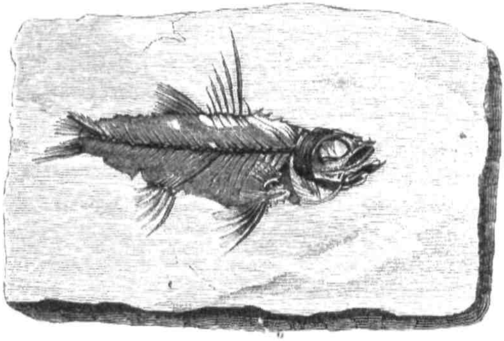
Beryx microcephalus (*Poiss. Foss.* tom. iv. tab. ivc.; and *Dixon*, *Foss. Sussex*, tab. xxiv. fig. 3).—This fish is distinguished by its slender form, and the extreme smallness of the head, as the name implies. The scales have one row of very thick spines on the posterior margin; they are more elevated, and shorter than in *B. radians*; those of the lateral line are pierced by an elongated conical tube, and are not ramified as in the last species. This ichthyolite, like the *B. radians*, occurs in the Chalk-marl, and in a similar state of mineralization.

Smerdis minutus. *Lign.* 203.—A pretty ctenoidian fish, from one to three inches long, about the dimensions of a perch a year old, is very common in the marls of Aix in Provence, *Wond.* p. 260; and many are often found grouped together in every variety of position. This species is characterised by the elevated anterior rays of the dorsal, and the wide and very forked caudal fin.

Several ctenoidian and cycloidian fishes have been found in the north of the Brazils, by Mr. Gardiner, in strata probably of the Cretaceous epoch.

Fossil Cycloid Fishes. (*Poiss. Foss.* tom. v.)—This order comprises the fishes possessing scales of a cycloid, or cir-

cular, form, with smooth margins, and composed of plates of horn or bone, without enamel. It contains numerous families, including the *Scaroids*, or Parrot-fishes, and the *Scomberoids*, or Mackerel tribe, which are Acanthoptery-



LIGN. 203. SMERDIS MINUTUS. *Eocene.* (*nat. size.*) *Aix in Provence.*

gians, the *Lucioids*, or Pikes, *Clupeoids*, or Herrings, *Salmonoids*, or Salmon tribe, and the *Cyprinoids*, or Carps, which are Malacopterygians, as well as other families. The fossil remains of this order are exceedingly numerous, particularly in the Tertiary and upper Secondary deposits. A genus of *Salmonidæ*, discovered in the White Chalk of Sussex, will serve to exemplify the characters of the fossil cycloidian fishes.

OSMEROIDES. *Plate II.* and *Wond.* p. 344, 347.—Two species of this genus occur in the Chalk, near Lewes; and principally, if not exclusively, in the Lower Chalk, without flints. They are exceedingly beautiful Ichthyolites, and are almost invariably found with the body but little compressed; the fish, in many examples, is as round and perfect as when living. The entire cranium, the opercula and branchial rays, and all the fins are preserved in some

examples. These fishes belong to the Salmon family,* and are nearly related to the SMELT (*Osmerus*); whence the name of the genus. There are two species, easily distinguishable. The first (*O. Mantelli, Pl. II.*) has a short, subcylindrical body, and seldom exceeds eight or nine inches in length; the other (*O. Lewesiensis*) has an elongated and elliptical body, and sometimes attains a length of fourteen inches. The dorsal fin too in this species has more rays than in the other. The fossil figured in *Pl. II.* is a very remarkable specimen of the first species. It is nine inches in length; and the chalk has been cleared away, so as to expose the entire fish, six inches in relief above the surface of the block, *Petrif. Lign.* 92, p. 445. The fish is lying on its back, with the mouth open, and the opercula, or gill-covers, and the branchial arches expanded; the pectoral and ventral fins, and the dorsal fin, are in their natural position; the five rays of the dorsal are erect; of the caudal fin, or tail, but slight indications remain. There is but one dorsal fin; but in a specimen of *O. Lewesiensis* there is a trace of the little adipose process observable between the dorsal fin and the tail, as in the recent species of *Salmonidæ*. A magnified view of one of the scales is represented *Lign.* 185, *fig.* 4, p. 567.

Of the CYPRINOIDS, or fishes of the Carp family (Malacopterygians), the recent species of which are inhabitants either of fresh-water, or the brackish waters of the mouths of rivers, many fossil species occur in the fluviatile and lacustrine deposits of the Tertiary formations. In their character of omnivorous fishes, the Carps then, as now, formed the principal mass of the finny population of the lakes, and in their turn served as food to the carnivorous tribes, as the pikes, eels, &c. Several species are found in a beautiful state in the schists of Œningen, and in the

* They were first described by me in *Foss. South D.* p. 235, tab. xxxiii. and xl. as *Salmo Lewesiensis*.

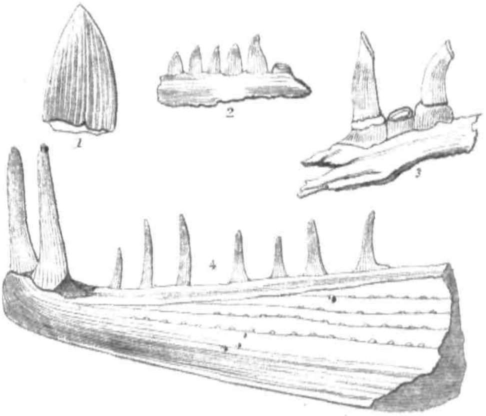
Tertiary marls at Aix. Many of the layers of marl at the latter locality are covered with groups of fishes of the family *Cyprinodonts*, the recent species of which are of a small size, and inhabit the fresh-water lakes of temperate zones. *Lign.* 184, p. 562, represents a portion of a large slab of marl in the cabinet of Sir R. Murchison, which is covered with scores of a species resembling a recent fish (*Lebias*) in the profile of its head, and the form of its fins. It is named LEBIAS CEPHALOTES, from the relative largeness of its head. The black appearance of the abdomen in many of these Ichthyolites indicates the original situation of the intestines and of the liver, which is largely developed in the fishes of this family, and contains much colouring matter.

SAUROCEPHALUS AND SAURODON. *Lign.* 204. — In the same quarry, near Lewes, from which the first entire fish of the Sussex Chalk was obtained, teeth of a very peculiar character were, many years since, occasionally discovered.* These teeth are of a lanceolate form, much compressed; with entire, sharp edges, terminating in a point; the fang is single, and broad; the surface of the crown is glossy, and marked with fissures filled with chalk (see *Lign.* 204, *fig.* 1). Teeth of this kind, attached to portions of the jaw, were subsequently found in the Chalk at Brighton and Lewes. Similar remains were collected from the Cretaceous marls of Missouri and New Jersey, in the United States. The American specimens comprised two closely allied genera, which, from the supposition that the fossils were the relics of reptiles, were respectively designated *Saurocephalus* and *Saurodon.*† Examples of the teeth and jaws of both genera have been discovered in the Sussex Chalk (see *Lign.* 204).

* Foss. South D. tab. xxxiii. p. 228.

† American Phil. Trans. vol. iii. new series, pl. xvi. on the *Saurodon*, by Dr. Hays; and Journal Acad. Sciences, Philadelphia, vol. iii. on the *Saurocephalus*, by Dr. Harlan.

M. Agassiz retains the names imposed by the American naturalists, and has placed these genera in the family of Scomberoids (*Mackerel, Swordfish*). They belong to the



LIGN. 204. FOSSIL TEETH AND JAWS OF FISHES. *Chalk. Sussex.*

Fig. 1.—Tooth of SAUROCEPHALUS LANCIFORMIS. *Lewes.*
2.—Teeth of SAUROCEPHALUS STRIATUS. *Brighton.* Portion of the jaw, with five teeth.
3.—Fragment of a jaw, with two perfect teeth, and the base of another, of SAURODON LEANUS. *Kemptown, Brighton.*
4.—ENCHODUS HALOCYON. Left branch of the lower jaw, with teeth; and one front tooth of the opposite portion. *Lewes.*

Pharyngognathi of Müller. The teeth are disposed in a single row, and fixed in deep sockets by a simple root, or fang, which is frequently somewhat excavated by the pressure of a successional tooth. In *Saurodon Leanus* the crown of the tooth is angular, and barbed, and supported on a subcylindrical shank, or stem (see *Lign.* 204, *fig.* 3). The microscopical structure of these teeth presents that peculiar reticulated disposition of the medullary canals throughout

the entire body of the tooth, which is only found in the dental organs of fishes.

HYPSODON LEWESIENSIS (*Foss. South D.* tab. xlii.).—The Sussex and Kentish Chalk also contain the remains of a very large fish, belonging to the Pharyngognathi, with extremely upright, long, conical, compressed, pointed teeth, which, like those of the Saurodon, are implanted in sockets. These teeth are commonly of a delicate fawn colour externally and of a dark brown internally; having a large simple pulp-cavity. In *Foss. South D.* (tab. xlii.) are represented portions of an intermaxillary and jawbone with teeth; a vertebra, deeply biconcave; and a large bone, apparently a branch of the *os hyoides;* all found in the same block of chalk.*

ENCHODUS (*sword-tooth*) HALOCYON. *Lign.* 204, *fig.* 4. (*Poiss. Foss.* tom. v. tab. xxv$^{c}_{a}$).—The specimen figured is a portion of the lower jaw, with one row of elongated, conical, slightly curved, pointed teeth; the two anterior teeth being much longer and larger than the others; it affords a good illustration of the dental organs of *Enchodus;* a genus of Acanthopterygian fishes, the jaws and teeth of which are often found in the Sussex Chalk. The teeth are of various sizes, and attached by anchylosis, one row on the premandibular bone, and another irregular row of smaller teeth to the inside of the lower jaw. The two anterior teeth are very large, and of a peculiar form: their base is wide and solid, and the shank of the tooth is suddenly contracted immediately above, and becomes elongated into a point. These teeth are generally of a dark colour, have a glossy aspect, and are very brittle; differing so remarkably in this respect from the shark's teeth, with which they are usually collocated, that mere fragments can be readily identified. The

* A magnificent specimen (now in the British Museum) displays, on the same slab of chalk, a large portion of the cranium, teeth, several vertebræ, ribs, and many other bones, belonging to a fish of considerable magnitude. *Petrif.* p. 444.

external surface of the lower jaw is marked with finely granulated, longitudinal ridges or striæ.*

Mr. Toulmin Smith, of Highgate, has in his Museum a portion of the lower jaw with fifteen teeth of a small individual, imbedded in the centre of a flint nodule, from Gravesend, which was discovered by accidentally breaking the stone. The bone of the jaw and the teeth are of a dead white colour, and appear not to be in the slightest degree silicified; but in those teeth which are broken the pulp-cavity is filled with quartz, which must have transuded through the walls of the teeth.

ICHTHYOLITES OF RECENT SPECIES.—The distinguished naturalist to whose labours in fossil Ichthyology we have been so largely indebted, states, that of the many hundred species submitted to his notice, but one can be identified with any fish now living. This conclusion must, however, be received with some reservation; for, among the fossil genera, founded on the teeth, there are species which certainly cannot be distinguished from recent forms. And in the diluvial drift at Breslau, associated with the bones of the fossil elephant (*Elephas primigenius*), the remains of a pike, closely resembling the common European species, have lately been discovered.†

The exception above alluded to, is a little Malacopterygian fish, rather larger than a Sprat, called the Capelan (*Mallotus villosus*), which inhabits the banks of Newfoundland, and other parts of the coasts of the northern seas. Fossil specimens of this fish ‡ occur in nodules of indurated

* A fine example of the lower jaw, with twelve teeth, is figured *Foss. South D.* tab. xli. and another, with the upper jaw and teeth, *Geol. S. E.* p. 140. Beautiful figures of the remains of Saurocephalus, Enchodus, Hypsodon, and many other fine Chalk fishes, are given in Dixon's *Fossils of Sussex*, 4to. 1850.

† Agassiz, *Poiss. Foss.* tom. v. p. 68.

‡ See *Poiss. Foss.* tom. v. pl. lx., in which the skeleton of the recent fish, and specimens of the fossil species, are represented.

marl or clay, on the coast of Greenland.* It is supposed that these Ichthyolites are of very recent date: and that similar fossils are in the progress of formation.

ICHTHYOPATOLITES, or imprints of the pectoral fin-rays of certain fishes. Under this name Dr. Buckland described certain problematical markings observed on a flag-stone from a coal-pit at Mostyn, in Flintshire, and now in the Geological Society's Museum. It consists of curvilinear scratches or imprints, disposed symmetrically at regular intervals on each side a smooth level space, about two inches wide, which may correspond to the body of a fish, the pectoral fins of which Dr. Buckland suggests were the instruments by which the markings in question were formed.

These scratches follow each other in nearly equidistant rows of three in a row, and at intervals of about two inches from the point of each individual scratch to the points of those next succeeding and preceding it; they are slightly convex outwards, three on each side the median space, or supposed track of the body of the fish. Dr. Buckland, in the memoir referred to, shows that these markings cannot be referable to the imprint of the feet or claws of reptiles, and points out the structure of the bony anterior rays of the pectoral fins, as in certain Siluroid and Lophoid fishes, and in the Climbing Perch (*Anabas scandens*), or the *Hassar* (*Doras costata*), and refers also to the ambulatory movements of the common Gurnard, in corroboration of this opinion.†

GEOLOGICAL DISTRIBUTION OF FOSSIL FISHES.—From the incidental notices of the geological habitats of the fossil fishes enumerated in our survey of this class of beings, the

* Similar fossils have been obtained from the "Drift" on the Saco River, thirty miles north of Portsmouth, New Hampshire. See Lyell's Second Visit to the United States, vol. i. p. 29.

† Proceedings of Geol. Society, vol. iv. p. 204.

reader cannot fail to have remarked, that the most recent strata abounded in forms related to the inhabitants of the existing seas and rivers; while the most ancient teemed with species and genera of families altogether extinct, or of prodigious rarity in the recent fauna.

In general terms, it may be stated, upon the authority of M. Agassiz, that the Ichthyolites of the Tertiary deposits approach in their characters to the living genera, but all the species are extinct. The newer Tertiary, as the Crag, contain genera common to tropical seas, as the large sharks (*Carcharias*), and eagle-rays (*Myliobates*), &c. In the Eocene, or most ancient Tertiary, as the London and Paris basins, Monte Bolca, &c., many of the Ichthyolites are closely related to recent genera. Of the Chalk fishes, a few only are of recent genera, but the majority are still allied to Tertiary forms. In the Chalk, the *Pharyngognathi*, *Acanthopteri*, and *Malacopteri* are met with as new types; and indications of the *Hybodontidæ*, *Sauroidei*, and *Cœlacanthi* (the last derived from the Devonian, and the other two from the Carboniferous Limestone) appear for the last time.

The ichthyic fauna of the Cretaceous deposits is closely related by the majority of its *family* groups with that of the series of strata from the Lias to the Wealden, inclusive. In and above the Lias all the ganoid fishes are *homocercal*. Below the Lias, the genera and species are far more removed from existing types, and almost all are *heterocercal*.

Of the eight thousand living fishes known to naturalists, three-fourths belong to the Cycloid and Ctenoid orders, and of these no species are known below the Chalk; the other fourth is referable to the Placoids and Ganoids, of which there are comparatively but few existing species. Yet fishes of these two orders almost solely flourished during the ancient Secondary formations; for below the Lias, the predominant recent orders are altogether absent.

Beneath the Coal, true carnivorous fishes, with trenchant teeth, are almost unknown; but omnivorous species, with either brush or obtusely conical teeth, and great sauroid fishes, are the prevailing representatives of the class.* In fine, the Ichthyolites of the different formations constitute two grand groups, which have their boundary line at the base of the Cretaceous deposits. The first and most ancient comprises the Ganoids and Placoids; the second, more intimately related to existing types, comprehends forms more diversified; these are principally Ctenoid and Cycloid, with a small number of the two preceding orders, which insensibly disappear; and their few living analogues are very distinct from the ancient species. Now, although deductions of this nature may require to be modified with the progress of knowledge, yet the generalizations thus obtained are founded on so vast an accumulation of facts and observations, as to render it improbable that they will be materially invalidated by future discoveries; for they remarkably accord with the results derived from the investigation of the fossil remains of all the other classes of animals. The most modern deposits contain the remains of animals allied to the existing species; the most ancient, of forms altogether extinct, or of excessive rarity in the recent faunas. The discovery of existing species, or genera, in the most ancient strata, would modify, but not destroy, the inferences deduced from the facts hitherto obtained; and every geologist is prepared to find that such may be the case.

Thus of the Sharks, with triangular notched teeth, which are so common in the Tertiary formations, and were for-

* In the several chapters on the different formations, as arranged in the *Wonders*, the student will find succinct notices of the distribution of the *genera* of fishes throughout the fossiliferous deposits. A list of the Chalk species known in 1848 is given at pp. 356—359, *Wond.*

merly unknown in the ancient Secondary, one representative has been found in the Carboniferous system (see p. 595). But, if teeth of this type should hereafter be discovered in every Secondary deposit, the great preponderance of these fishes over the Sauroid in the Tertiary, and in the existing seas, would not be the less remarkable.

ON COLLECTING AND DEVELOPING FOSSIL FISHES.—From what has been advanced, the reader will have obtained a general knowledge of the fossil remains of this class that are likely to be met with in particular deposits. Thus, he will expect to find the teeth of large sharks and rays in the Tertiary clays and sands; and skeletons and perfect specimens of numerous Ctenoid and Cycloid fishes in the laminated marls and fine limestones of the same formations. In the Chalk, with numerous teeth of sharks, he may discover splendid examples of Cycloid and Ctenoid fishes; and, in the Wealden, large Ganoidian forms. Passing to the ancient Secondary strata, the extraordinary buckler-headed and Sauroid fishes will arrest his attention; and their vestiges will be found, more or less perfect, in the shales and limestones, and in the indurated nodules of clay and sandstone.

The detached teeth of fishes in Tertiary sands and clays may be easily obtained entire, and should be arranged in the same manner as the shells (see p. 442), either in trays, or on boards. The triangular teeth, with lateral denticles, must be carefully extracted, so as to preserve those appendages on which the specific and generic distinctions of many Ichthyolites depend. M. Agassiz particularly recommends the preservation of all the specimens collected together in the same locality, as many may probably belong to the same individual, and thus the dental organization of the

original be determined. Teeth collected from the same stratum in different places, should not, therefore, be mixed together. Several series of the same kind of teeth should be preserved, and as many as possible of each kind; for specimens apparently identical may prove to be highly instructive as a series. I have often had occasion to regret the disposal of supposed duplicates, in my earlier researches, which would have tended to elucidate the characters of those specimens which were retained.

The Ichthyolites, and their detached teeth and fins, in the Chalk and other soft limestones, may be cleared by means of a penknife or graver and small sharp chisels. It is preferable to leave the teeth attached to small blocks of the chalk; as in the examples, figured *Lign.* 193. But to develop the beautiful Chalk Ichthyolites, particularly those of the Osmeroides, Macropoma, &c. some practice and considerable dexterity are required. The compressed fishes, as the Beryx, like those in the Tertiary limestones, often lie in the sedimentary plane of the stone, and may be sufficiently exposed, by a blow of a hammer or a pick, to show the nature of the fossil, and admit of being easily developed. But the fishes with subcylindrical bodies very commonly split asunder in a transverse direction: and those with spinous scales, as the Macropoma, adhere so firmly to the chalk, that, to display the external surface of their scales, the surrounding stone must be removed piecemeal, in the manner described for the Chalk crustaceans (see p. 544). The collector who sees the splendid Chalk fishes in the British Museum,* and learns that they were found in the Chalk of Kent and Sussex, will be grievously disappointed, upon visiting the quarries from which they were obtained, if he expects to discover specimens with any considerable portion of the scales, or body, exposed. It was many years before the quarry-men acquired the tact they now possess, of

* *Petrifactions*, pp. 441, 444.

detecting, from very slight evidence, the presence of an Ichthyolite in a block of chalk: patches of scales, which the quarry-men called "*bran*," and detached sharks' teeth, "*birds' beaks*," and "*snakes' tongues*," and teeth of Ptychodus, "*slugs*," being the only remains of fishes generally observed and laid aside by the workmen.

The fossil *Salmon* or *Smelt* (see p. 626), which may be considered as one of the most extraordinary of the Chalk fishes found in England, affords an excellent illustration of the mode of developing the Ichthyolites of this formation. This interesting fossil is delineated on a small scale, in three different states, in *Plate II.*; and affords a good practical lesson for the young collector. Among some blocks of chalk which a recent fall in one of the quarries near Lewes had brought to light, was a large mass split asunder, and exposing on each corresponding surface an irregular oval marking of a yellowish brown colour; this appearance is represented *Pl. II. fig.* 1. Presuming that these markings were produced by a transverse section of the body of a fish, the two blocks were trimmed into a portable size, and accurately cemented together with very *hot, thin, fresh* glue. When consolidated, some of the chalk was chiselled off in the supposed longitudinal direction of the enclosed fish, and part of the body, covered with scales, was exposed, as *Pl. II. fig.* 2. With the view of ascertaining the extent of the Ichthyolite, some of the surrounding stone was then removed towards each extremity of the block, and traces of the fish were discovered, as shown in the same figure. The task of completely developing the fossil was thus rendered comparatively easy; the chalk was chiselled, cut, and scraped away, till the perfect fish, as seen in fig. 3, was developed.* The block was then reduced to a convenient size,

* The figure in *Pl. II.* is too small to convey an accurate idea of this Ichthyolite, which is now in the British Museum; see *Petrifactions*, pp. 445, 446. M. Agassiz's figure very inaccurately represents

and the edges sawn smooth. The chalk is easily cut with a carpenter's saw; the instrument should be short and strong, and the teeth of moderate size.

When a *portion* of the body of an Ichthyolite of this kind is found in a block of chalk, and the fracture of the block appears to be recent, diligent search should be made for the corresponding piece; for it may probably be found to contain the other part of the fish. A splendid specimen of *Osmeroides Lewesiensis*, more than a foot long, was thus obtained. The quarry-men, in a block of chalk which a recent fall had thrown down, discovered a few inches of the *caudal portion of the body of a fish; on the broken surface* of the stone, a section of the body was distinctly seen, as in the specimen previously described. Search was made among the fallen masses for the corresponding piece, but without success. Upon observing the face of the quarry exposed by the recent fall, on a projecting block, many yards above our reach, a discoloured spot was indistinctly seen, and it was conjectured that this might prove to be the other moiety of the Ichthyolite. The workmen were directed to preserve this block if possible; but it remained *in situ* several months, and until the rock was again blasted; when the stone so long coveted rolled away from the fallen mass, and fortunately was soon discovered. It proved to be the *corresponding portion of the fish; with the head, opercula,* branchial arches, pectoral fins, and the anterior part of the body covered with beautiful cycloid scales. In the preparation of fossils of this kind, glue as the cement, and a paste made of plaster of Paris with thin glue, to fill up the crevices and strengthen the block, are the materials I have employed. The fossil remains of fishes in other rocks require to be extracted and developed in the manner previously

the original. A beautiful lithograph of this fish, by Mr. Pollard, of Brighton, was published in the Catalogue of the Mantellian Museum, 1836.

directed for the Echinoderms, Cephalopoda, &c. (pp. 332, 497.)

The collector may be reminded, that *Otolithes*, or ear-stones (p. 574), are found in the Crag of Norfolk, and other Tertiary strata; and that Coprolites, associated with minute scales, bones, &c. of small fishes, constitute, in some localities, layers of considerable thickness and of great extent. The "*bone-bed*" of the Lias, near Westbury, and that of the Ludlow series on the banks of the Teme, near Ludlow,* are well-known examples of such a deposit.

Microscopical Examination. — A few words on the microscopical examination of the remains of fishes may be useful. The structure of the large, and the forms of the minute scales, may be seen by a common lens, and without preparing the specimens. But for the examination of the intimate organization of scales, teeth, &c. the microscope is required; and the method directed for the investigation of flint (p. 373) should be employed. The scales, portions of the membranes of the air-bladder, stomach, &c. and thin chips of the teeth, rendered temporarily transparent by oil of turpentine, or permanently so by Canada balsam, should be viewed by transmitted light. But the intricate structure of the dental organs, the medullary canals, and the calcigerous tubes, cannot be successfully investigated without the aid of the lapidary, or the adoption of the process described at page 67 for the preparation of fossil wood for microscopical examination.

* See Mr. Strickland's interesting notice of the distribution and contents of this "bone-bed," in the Quart. Geol. Journ. vol. ix. p. 8

Glaris, Switzerland. *Cret.* Immense numbers of fishes in dark schist. The specimens are often contorted, from the contraction of their bodies, during decomposition.

Maestricht (St. Peter's Mountain). *Upper Cret.* Numerous teeth, vertebræ, &c. of fishes of the Cretaceous epoch. See *Wond.* p. 309.

Mansfeld, in Thuringia. *Permian.* Fishes in copper-slate, in great numbers; many extremely beautiful.

Monte Bolca, or Vestena Nova. *Tert.* The richest mine of Ichthyolites in the world. A catalogue of the numerous genera and species found in this celebrated locality, is given in *Poiss. Foss.* tom. iv. pp. 33—52.* See *Wond.* p. 265.

Mount Lebanon, Asia. *Tert.* Numerous Ichthyolites, in great perfection.

Œningen. *Tert. fresh-water.* Many kinds of fishes of the same genera as those which inhabit the great European lakes; as the Perch, Salmon, Eel, Pike, Carp, &c. A list of these Ichthyolites will be found in *Poiss. Foss.* tom. ii. part ii. p. 78. See *Wond.* p. 263.

Saarbrück, in Lorraine. *Carb. Amblypterus,* and other Carboniferous fishes.

Seefeld, in the Tyrol; on the principal road from Inspruck to Munich. *Lias.* Abundance of fish in bituminous slate.

Stabia, Italy, at Torre d'Orlando, near Castellamare. *Oolite.* Beautiful fishes in fissile limestone.

Solenhofen. *Oolite.* Numerous Ichthyolites; many in great perfection. See *Wond.* p. 513.

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* It is necessary to caution the collector against the frauds practised by the quarry-men, and dealers in fossils, at this and other celebrated foreign localities. Specimens, apparently perfect, are ingeniously constructed from the fragments of various examples. The head of one fish, the body of another, decorated with the fins of a third, and perhaps the tail of a fourth, of different species, or even genera, are dove-tailed together, coloured, and varnished, so as to deceive the common observer, and, occasionally, even the experienced collector. Sponging the specimens with cold water will often detect the imposition; for the colour if artificial will be removed, or rendered paler, while the same process will heighten the natural tints. At Pappenheim, Solenhofen, and other places, where fossil crustaceans, as Shrimps, Prawns, &c. are found in such perfection, the *imprints* of good specimens are often coloured, and offered for sale: a wet sponge will speedily detect the imposture.

CHAPTER XVI.

FOSSIL REPTILES; COMPRISING THE ENALIOSAURIANS AND CROCODILES.

"Nous remontons donc à un autre âge du monde; à cet âge où la terre n'étoit encore parcourue que par des reptiles à sang froid—où la mer abondoit en ammonites, en bélemnites, en térébratules, en encrinites, et où tous ces genres, aujourd'hui d'une rareté prodigieuse, faisoient le fond de sa population."—CUVIER, *Oss. Foss.* tom. v. p. 10.

WE advance now to the investigation of the fossil remains of the more highly organized classes of the VERTEBRATA; the Fishes being the lowest in the scale amongst the beings characterised by an osseous skeleton, with a flexible spinal column, composed of articulated bones, and presenting, in the various classes, orders, genera, and species, numerous modifications of form and structure. The mineralized relics of the vertebrated animals consist, for the most part, of single and displaced bones, or groups of bones and teeth, and the durable portions of the dermal integuments; entire skeletons being of rare occurrence. A knowledge of anatomy and physiology, and access to anatomical and zoological libraries and collections, are therefore indispensable for the cultivation of this most attractive department of Palæontology. Fortunately for the English student, this branch of the science, which a few years since was but little cultivated in this country,* has been greatly advanced, by the liberal

* See *Petrif.* p. 226, note.

support afforded by the British Association of Science to Professor Owen, whose Reports on the British Fossil Reptiles and Mammalia, published in the Transactions of the Association,* should be referred to for more precise and detailed information than can be given in these unpretending volumes. Our remarks will be limited to a general notice of the fossil remains of Reptiles, Birds, and Mammals; with descriptions of such characteristic examples, as will serve to illustrate the nature of the specimens that may probably come under the notice of the collector; or which, from their peculiar characters, are objects worthy his special attention.

THE AGE OF REPTILES.†—The announcement by the illustrious founder of Palæontology, in the quotation prefixed to this chapter, that there was a period when the lakes, rivers, and seas of our planet were peopled by reptiles, and when cold-blooded oviparous quadrupeds, of appalling magnitude, were the principal inhabitants of the dry lands, was a proposition so novel and startling, as to require the prestige of the name of CUVIER to obtain for it any degree of credence, even with those who were prepared to admit that a universal deluge could not account for the physical changes, which the crust of the earth had evidently undergone. Subsequent observations and discoveries have, however, fully confirmed the truth of this induction, and the "*Age of Reptiles*" is no longer considered fabulous.

* Report of the Brit. Assoc. 1839 and 1841; see also Trans. Geol. Soc. 2d ser. vol. v. p. 515 (1838).

† "*The Age of Reptiles*" was the title given by the author to a popular summary of the evidence bearing on this question: it was published in the Edinburgh Philosophical Journal, 1831. This name is now generally employed to designate the geological epochs characterised by the predominance of oviparous quadrupeds; namely from the Permian to the Chalk, inclusive.

In some of the ancient fossiliferous deposits,* indications of the existence of Reptiles are visible, in the indelible markings left by their footsteps on the muddy banks of rivers, and on the wet sands of the sea-shores, now in the state of layers of marl and sandstone. Here and there in the Devonian,† Carboniferous, and New Red formations, teeth and bones are found, presenting unequivocal proofs of the presence of extinct forms of cold-blooded oviparous quadrupeds. As we ascend in the secondary formations, we are suddenly surrounded by innumerable marine and terrestrial reptiles, belonging to species and genera, and even orders, of which no living representatives are known. Throughout the Liassic, Oolitic, Wealden, and Cretaceous epochs, the class of Reptiles was at its fullest development. In the Tertiary periods which succeeded, the Reptiles approach the recent types, and their relics are found intermingled with the bones of mammiferous quadrupeds; thus indicating the commencement of the present condition and relations of the animal kingdom. Referring the reader to *Bd.* p. 165, and *Wond.* pp. 409—444 and 567—588, for a more comprehensive view of this subject, we advance to the examination of some of the fossil genera and species; and we propose, in the first place, to explain a few essential characters of form and structure observable in those durable parts of the skeletons which are most frequently met with in a fossil state; namely, the teeth, jaws, vertebræ, &c., and the osseous appendages of the dermal system.

The animals comprehended in the Class of REPTILIA constitute, according to Prof. Owen's arrangement, eight principal groups, or Orders, as follow:—

* Devonian rocks of Elgin, North Britain; and the Lower Carboniferous of Pottsville, Pennsylvania.

† The most ancient Reptile hitherto discovered is the *Telerpeton Elginense*, from the Old Red of Scotland, which will be described in the sequel.

The *Batrachia;* Frogs: the body naked, with only rudimentary ribs; and with two or four feet. Most of these reptiles breathe by branchiæ or gills in their young state, and by lungs in the adult (as for example the Frog); in some (the *perenni-branchiata*), the branchiæ are persistent through life.

The *Ophidia;* Serpents: the body destitute of feet.

The *Lacertia* or *Sauria;* Lizards: the body supported by four or two feet, and covered with scales.

The *Chelonia;* Tortoises: the body supported by four feet or paddles, and enveloped in two osseous bucklers, composed of the expanded bones of the sternum and thorax.

Having a tripartite heart (*i.e.* with two auricles and one ventricle), and simple transverse processes to the cervical and anterior dorsal vertebræ.

The *Enaliosauria;* Sea-saurians (*extinct*): body furnished with four paddles, and destitute of scaly covering.

The *Pterosauria;* Wing-saurians (*extinct*): body supported on four feet, the outer finger of each fore-foot greatly lengthened, and forming a support for the wing.

The *Crocodilia;* Crocodiles: body supported on four partially webbed feet, and encased with an armour of bony plates or scutes.

The *Deinosauria;* Great-saurians (*extinct*): body supported on four feet.

Having a quadripartite heart (*i.e.* with two auricles and two ventricles), and double transverse processes to the cervical and anterior dorsal vertebræ.

TEETH OF REPTILES.—The teeth of the animals of this class exhibit considerable diversity of form, but the characteristic type is that of a conical, pointed tooth, with a simple root or fang; for, *in no reptile does the base of the tooth terminate in more than one fang, and this is never branched.* "Any fossil, therefore, which exhibits a tooth implanted by two fangs in a double socket, must be mammiferous, since the socketed teeth of reptiles have but a single fang; and the only fishes' teeth which approach such

a tooth in form, are those of a bifurcate base, belonging to certain sharks." (*Owen.*)

These dental organs are only fitted for seizing and retaining the prey or food; for no living reptiles have the power of performing mastication. In the Crocodiles the tooth has a cylindrical shank, with a conical, longitudinally striated, enamelled crown, having a ridge on each side (*Pl. VI. fig.* 5). In the *Labyrinthodon* (a fossil reptile), the cone is more curved and pointed (*Pl. VI. fig.* 3); in the *Hylæosaurus*, the shank is cylindrical, and the crown expanded and lanceolate, with blunt margins (*Pl. VI. fig.* 6); in the *Megalosaurus*, the tooth is laterally compressed, trenchant, and slightly inclined backwards like a sabre, with serrated edges (*Pl. VI. fig.* 7); in the *Iguanodon*, the shank is cylindrical, and the crown of a prismatic form, greatly expanded, with broad denticulated edges, and longitudinal ridges on one side (*Pl. VI. fig.* 4, and *Ligns.* 221, 223). In the Serpents, the teeth are very long and pointed; in the Crocodiles and Lizards, may be seen every modification of the conical form, down to a mere hemispherical tubercle or plate. In the fossil *Dicynodon*, to be hereafter described, the dental system consists of but two tusks or canine teeth, like those of the Walrus, implanted in the upper jaw. The Turtles and some fossil Lacertians are *edentulous*, *i.e.* destitute of teeth; their dental organs consisting of the horny trenchant sheaths with which the jaws are covered.

The teeth are very numerous in reptiles; the individuals of some species have more than two hundred. In some genera, they are implanted on the jaws alone; in many, they occupy the palatine, vomerine, and other bones composing the vault of the mouth, as in certain fishes. The teeth are generally anchylosed to the bone; but in some genera they are implanted in distinct sockets, as in the Crocodile and Plesiosaurus; in others, as in the Ichthyosaurus, they are arranged in a deep furrow, and retained

only by the integuments; in some, they are supported upon an elevated osseous base. In the Labyrinthodonts, and in the greater part of the Serpent tribes, the tooth is implanted by the base in a shallow socket, with which it is confluent.

In most of the Lacertians, or true Lizards, the attachment of the teeth presents a peculiar modification, of which the lower jaw of the Iguana, *Lign.* 205, p. 649, affords a good illustration. The teeth are not placed in sockets, but are attached by the shank to an alveolar plate, or parapet, that extends along the margin of the jaw, as shown in *figs.* 1 and 3; the crowns of the teeth project above this plate, as seen in *figs.* 2 and 4. From the anchylosis of the teeth to the side of the jaw, the Lizards possessing this dental structure are termed *Pleurodonts.**

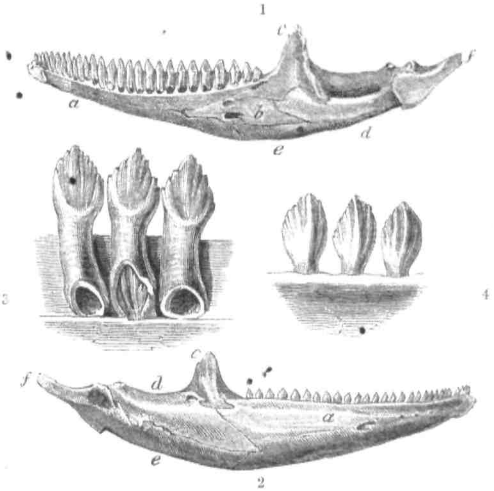
In reptiles, we have, therefore, five essential modifications in the attachment of the teeth; namely, in distinct sockets; in a continuous groove or furrow; attached laterally by the shank to an alveolar parapet; anchylosed by the base to a shallow socket; and attached to an osseous support, without sockets or an alveolar plate.†

The intimate structure of the teeth consists of a simple pulp-cavity, surrounded by dentine, which is permeated by extremely minute calcigerous tubes, radiating at right angles to the periphery, or external surface of the tooth. One essential modification of this structure consists in the intermingling of cylindrical processes of the pulp-cavity, in the

* The *Pleurodonts* are those lizards in which the teeth are anchylosed to the *side* of the dentary bone; *Acrodonts*, those with the teeth fixed to the upper margin or *ridge* of the jaw-bone; *Thecodonts*, those having the teeth implanted, either loosely, or anchylosed to the walls of their sockets. Lacertians are also said to be *Pleodont* (having solid teeth), or *Cœlodont* (hollow-toothed).

† See the beautiful exemplification of this subject, and the comparison between the transitory stages of the human teeth in their progress of development, discovered by Mr. Goodsir, with the permanency of these conditions in reptiles. Odontography, p. 182.

form of medullary or vascular canals, with the finer tubular structure; as in the tooth of the Iguanodon, *Pl. VI. figs.* 4[b]



LIGN. 205. THE LOWER JAW OF AN IGUANA.

(*From Barbadoes.*)

Fig. 1.—The right branch of the lower jaw of an IGUANA; viewed on its inner aspect. *Nat. size.*

- *a*. Dentary bone.
- *b*. Opercular bone.
- *c*. Complementary or coronoid bone.
- *d*. Surangular bone.
- *e*. Angular bone.
- *f*. Articular bone.

2.—The external aspect of the same.

3.—Inner aspect of three teeth (*magnified*) attached to the alveolar parapet; with the germ of a successional tooth at the base of the middle tooth; and the sockets of other germs at the bases of the outer two fully formed teeth.

4.—External view of the crowns of three teeth; slightly magnified.

and 4[c]. But another modification is that to which allusion was made when describing the teeth of the Lepidosteus (see

p. 616); in this mode, the dentine preserves its normal character, but the external cement and surface of the tooth are deeply inflected in longitudinal folds around the entire circumference; and this structure is accompanied with corresponding extensions of the pulp-cavity and dentine into the interspaces of these inflected and converging folds.* This organization is shown, in its simplest form, in the transverse section of the base of a tooth of the Ichthyosaurus, *Pl. VI. fig.* 9; and attains its most complicated condition in that of the Labyrinthodon, *Pl. VI. figs.* 3^a, 3^b, 3^c.

With regard to the mode of development of the teeth, we must briefly state, that the germ of the new tooth is always produced at the side of the base of the old one; that in its progress of growth it presses against the tooth it is destined to supplant, occasions the progressive absorption of the fang, and ultimately displaces its predecessor; in some instances, by splitting the crown of the tooth; in others, by casting it off, according to the oblique or direct position the new tooth attains in its progress, in relation to its predecessor. Thus, in the teeth of the Crocodile, the new tooth is generally found immediately under the conical apex of the crown, and beneath the former a second successional tooth appears, like a series of thimbles of various

* There is a marked difference between the internal structure of the teeth of true Saurians and of Sauroid Fishes. In the former, as well as in the *Enaliosauria*, the dentine consists of tubes radiating from a slender central pulp-cavity to the periphery of the tooth, without any intermixture of vascular canals. In the sauroid fish (*Dendrodus*) the central pulp-cavity is produced into numerous irregular canals, from which vascular sinuses radiate to the periphery, sending off branches generally at right angles throughout their entire course; thus, there is an extensive distribution of the vascular system through the body of the tooth, which does not exist in any saurian reptile; the nearest analogy is in the labyrinthine teeth of the gigantic fossil batrachians. (*Owen:* Odontography; and Art. TEETH, Cyclop. Anat.)

sizes placed one upon another; for in reptiles the production of new teeth is unlimited. But in the *Pleurodont* lizards, the new tooth makes its way obliquely, and the crown is often shed entire. *Lign.* 205, *fig.* 3, exemplifies the situation of the successional teeth in the Iguana.

LOWER JAW OF REPTILES.—It is well known that the lower jaw in mammiferous animals is composed of a single bone on each side; and that in many genera these pieces become united in front, and form but one bone in the adult state. But in reptiles, the lower jaw consists of six distinct bones on each side, as in *Lign.* 205; and these undergo various modifications of form and arrangement in the different genera. These bones are distinguished by names which have reference to their office and situation, and are as follow: —*Lign.* 205, *a*, the *dentary* bone, supporting the teeth; *b*, the *splenial* or *opercular*; *c*, the *coronoid* or *complementary*; *d*, the *sur-angular*; *e*, the *angular*; *f*, the *articular*, which forms the upper portion of the jaw, and includes the condyle. The form and disposition of these bones in the Iguana, and other true lizards, are shown in *Lign.* 205; but they differ materially in the Crocodile, Ichthyosaurus, and other genera. We must restrict our comments to this short notice, which, however, will suffice to enable the collector who discovers a fragment of a lower jaw, with any traces of the structure above described, to determine that it is reptilian; and if any portion of the *dentary* bone remains, indications may be obtained of the family, and perhaps genus, to which it belonged.*

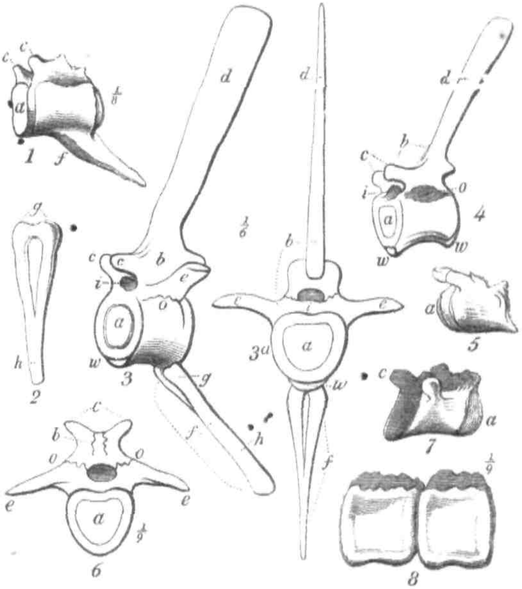
VERTEBRÆ OF REPTILES.—The bones of the vertebral column of this class of animals present such numerous and

* To obtain a correct knowledge of the osteological structure of fossil Reptiles, the student should consult Baron Cuvier's *Ossemens Fossiles*, tom. v. To the English reader, the translated abridgement of Cuvier's "Fossil Remains of the Animal Kingdom," by E. Pidgeon, 1 vol. 8vo. with plates, 1830, will be found a very instructive volume. See also Penny Cyclopædia, Art. SAURIANS.

important modifications in the different orders and families, that reference to the works already cited must be made for satisfactory information on this topic. From the great number of vertebræ in many reptiles, amounting in the individuals of some species to nearly two hundred, these bones are the most abundant fossil relics of these animals to be found in our collections. The vertebræ are commonly detached, and deprived of their processes; the solid *centrum*, or body, alone remaining in most examples (as in *Lign.* 206, *fig.* 8). Connected series, more or less complete, are occasionally discovered; and the entire column, in connexion with other parts of the skeleton, is preserved in many specimens in the British and other museums.* Although, for the reasons previously stated, minute osteological details cannot be attempted in this work, some acquaintance with the elementary characters of the bones composing the spinal column, and of the nomenclature employed to distinguish them, is necessary to guide the student, and even the amateur collector, in their researches. I have, therefore, selected a few specimens from Tilgate Forest in illustration of the elements of Saurian vertebræ, and of the terms by which the different processes are distinguished; the general reader will thus be enabled to comprehend the descriptions of these structures in other works on Palæontology.

The bones composing the spine, are not only designed to form a flexible column of support to the trunk, but also to afford protection to the grand nervous chords constituting the spinal marrow, and which extend from the brain to the tail, and give off numerous lateral branches in their course, conferring sensation and motive power to every part of the frame. To effect this purpose, there is attached to the upper or dorsal part of each vertebra a bony ring, called the *neural-arch*, which is composed of two processes (*Lign.* 206, *b.*), arising from each side of the body or *centrum* (*Lign.*

* See *Petrifactions*, pp. 136—352, and pp. 362—387.



LIGN. 206. FOSSIL VERTEBRÆ OF REPTILES. *Tilgate Forest.*

The figures are reduced in the proportions specified by the fractions.

Fig. 1.—Caudal vertebra of an unknown reptile.

2.—Chevron bone of IGUANODON : seen in front.

3.—Caudal vertebra of IGUANODON, viewed laterally in an oblique direction.

3*a*.—Front view of the same.

4.—Caudal vertebra of IGUANODON, without either transverse process or chevron-bone. The letter *o* marks the deep hollow left by the removal of the transverse process, at the suture of the annular part.

5.—Vertebra of STREPTOSPONDYLUS : $\frac{1}{10}$ *nat.*

6.—Lumbar vertebra of IGUANODON, with the neural spine broken off.

Fig. 7.—Vertebra of STREPTOSPONDYLUS : $\frac{1}{10}$ *nat.*

c. The pair of posterior oblique processes (*zygapophyses*).

[*Continued over.*

8.—The bodies of two dorsal vertebræ of IGUANODON: viewed laterally.

The same letters refer to the same parts in the respective figures, with the exception of *c* in fig. 7.

a. The body, or *centrum*, of the vertebra: the letter denotes the anterior part.

b. The annular part, formed of the two *neurapophyses*, which contains the spinal cord.

c, *c*. The articular or oblique processes (*zygapophyses*), which join to the next vertebra in front.

d. The spinous process or neural spine of the annular part.

e, *e*. The transverse process of the annular part.

f. The chevron-bone, formed of the two *hæmapophyses* and the hæmal spine.

g. The double articulating head of the chevron: the passage left by these processes (*hæmal arch*), seen in the front view, figs. 2 and 3, is for the passage of the large blood-vessels which supply the tail.

h. The spine of the chevron-bone; the inferior spinous process, or *hæmal spine*.

i. Denotes the medullary cavity of the annular part.

o, *o*. Mark the sutures which connect the annular part with the body of the vertebra.

w. *w*. Indicate the place of attachment of the chevron-bone.

206, *a*.), and which unite above into a solid piece, termed the *spinal process*, or *neural spine* (*Lign*. 206, *d*.). On each side of the annular part there is a process, called the *transverse* (*Lign*. 206, *e*, *e*.), for the attachment of muscles; and in the middle and the posterior dorsal regions of some reptiles, as, for example, in the existing Crocodiles, these processes articulate with the ribs. The vertebræ of the tail have, in addition to the above, an inferior spinous process, termed the *chevron-bone* (*Lign*. 206, *fig*. 2, and *fig*. 3, *f*.), which gives support to the inferior layers of the caudal muscles; and, bifurcating at its attachment to the body of the vertebra, leaves a channel for the passage of the large blood-vessels, by which the circulation of the tail is effected.

In the generality of living reptiles (as, for example, in the Crocodile) the bodies of the vertebræ are concave in front, and convex behind; the bones of the spine being united by ball-and-socket joints; but, in most fossil reptiles, both faces are either flat, or more or less concave. In mammalian

quadrupeds, the annular part is anchylosed to the vertebral centre; but in reptiles, it is united by suture, although, in old subjects, the connecting line is often obliterated. By reference to *Lign.* 206, and its description, the form, arrangement, and connexion of the different vertebral elements, in certain fossil reptiles, may be easily understood. The bones in the vertebral column of the same animal are considerably modified in the several regions of the neck (*cervical* vertebræ), back (*dorsal* and *lumbar*), and tail (*caudal*). The cervical are generally of the most complicated structure; and the caudal, the most simple.

From this exposition, the reader will perceive that every vertebra consists of the following essential parts: first, the body, or *centrum;* and secondly, the annular part, or *neural arch,* so named, because it protects the nervous chord; while a caudal vertebra has, in addition, the *chevron-bone,* called also the *hæmal arch,* from its affording a passage to the large blood-vessels. The bodies of the vertebræ are in general solid, and consist of the ordinary osseous structure; but in certain fossil vertebræ the centre of the bone is filled with calcareous spar, indicating an irregular medullary cavity, as in the caudal vertebræ of the Ox.*

The *Sacrum,* which may be termed the key-stone of the pelvic arch, is formed in existing reptiles by the union of two vertebræ; but in the Iguanodon and the Hylæosaurus the sacrum is composed of six anchylosed vertebræ; in the Megalosaurus probably of but five.†

From the sides of the two anchylosed vertebræ which form the sacrum, strong, short, rib-like processes are given off in those Saurians which occasionally walk on dry land, and these constitute a firm support to the hinder extremities.

In the Crocodiles, the four or five vertebræ preceding the

* See *Petrifactions*, p. 166, *note.*

† Report, Brit. Assoc. 1841, p. 105, and p. 130.

sacrum have no ribs attached to them, and are termed *lumbar*; in the Lizards, there are but two lumbar vertebræ. A peculiar modification exists in the first caudal vertebra of the adult Gavial and Crocodile; the *centrum* is *convex* both in front and behind, as was first demonstrated by me in 1836. See *Wond.* p. 419, and *Petrif.* p. 167. The last of the anchylosed vertebræ forming the sacrum is concave posteriorly; hence the necessity of an anterior ball in the first joint of the tail. (See *Lign.* 217, p. 676, illustrative of *Crocodilus Hastingsiæ.*) The last *cervical* vertebra in the Turtles and Tortoises has a similar construction. This mechanism confers freedom of motion without risk of dislocation.

RIBS.—The Ribs, which are regarded as appendages to the vertebræ, (homologues of the pleurapophyses,) are generally slender and round in the Lizards, and articulate with the spinal column by a single head, supported on a short convex process or tubercle. In Crocodiles only of all existing Reptiles, but in several extinct genera, the proximal end of the rib forms a double articulation, by a distinct head and a tubercle, with the vertebræ in the cervical and anterior dorsal region of the spinal column; in the posterior dorsal region the ribs are attached to the elongated transverse processes of the vertebræ.

As this double articulation of the ribs is invariably associated in existing reptiles with a heart having double ventricles, while the lacertian single-headed ribs are in like manner connected with a heart having but one ventricle, the student will perceive the important physiological inferences that spring from the discovery of a mere fragment of a rib, when interpreted by the profound anatomist.* In some fossil reptiles the ribs are flat and very broad; as, for example, in the Hylæosaurus.†

* See Brit. Assoc. Report, 1841, and Memoirs, Palæont. Soc.

† In Crocodiles the abdominal region is strengthened by slender

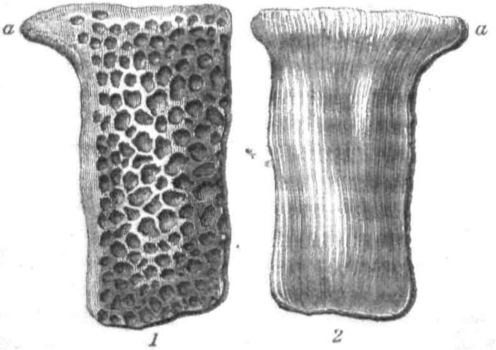
EXTREMITIES.—The locomotive extremities are variously constructed, according to the adaptation of the animals to a terrestrial, fluviatile, or marine existence. The bones of the limbs in the extinct colossal terrestrial species much resemble those of our large pachydermata, the Rhinoceros and Hippopotamus. The cylindrical bones of the extremities in the Crocodilians, and other recent reptiles, are solid, *i. e.* have no cavity filled with marrow; such also is the case in the fossil Enaliosaurians; but the thigh-bones and leg-bones of the Iguanodon, and of other extinct land saurians, have a large medullary canal. Our limits will not admit of further osteological details; and we are compelled to omit the description of the bones composing the thoracic and pelvic arches.

DERMAL BONES. *Ligns.* 207 and 208. In many of the reptile tribes, particularly of the Crocodilian or loricated (*mailed*) group, there are immediately under the external integument or skin a series of osseous *scutes*, or scutcheons, variously arranged, which serve as supports to the integumental scales and spines. In the gigantic Gavial, that inhabits the Ganges and other rivers of India, and which is remarkably distinguished from the common Crocodile and Alligator by an extremely elongated slender muzzle, the nape of the neck is protected by sixteen or eighteen transverse rows of dermal scutes; and there are likewise six rows which extend down the back. These bones are

ribs (*hæmapophyses*, Prof. Owen), that are affixed to a ligamentous extension of the cartilaginous sternum, analogous to the *linea alba* in man; and the Hylæosaurus appears to have possessed a similar development of the costal elements, for I observed many fragments of long, slender, subcylindrical rib-like bones whilst chiselling off the stone from this species, and portions of similar bones occur in the stone around the spinal column from Bolney. In the Maidstone Iguanodon there are likewise some long slender bones of this character, which I think must be prolongations of the ordinary dorsal ribs.

deeply corrugated or sculptured on their upper surface; a structure adapted for the firm adhesion of the horny integument.

Detached bones of this character occur in the Purbeck strata; and the first fragments I collected were supposed by me to belong to the soft-skinned turtles (*Trionyces*); but the subsequent discovery of perfect scutes demonstrated their analogy to the dermal bones of the Gavial, and enabled me to determine their true character.



LIGN. 207. DERMAL BONE OF THE SWANAGE CROCODILE: ½ nat. *Purbeck*.

(GONIOPHOLIS CRASSIDENS.)

Fig. 1.—The external aspect.
2.—The inner surface.
a.—The lateral connecting process.

In the splendid specimen of the fossil remains of a Crocodilian reptile (*Goniopholis*), found at Swanage (*Wond.* p. 415; and *Petrif.* p. 170), there are numerous dermal *scutes* dispersed among the bones, as shown in *Petrif. Lign.* 38. One of these is figured *Lign.* 207; *fig.* 1 represents the external surface, which is deeply sculptured by irregular

roundish pits or excavations; the under or inner surface, *fig.* 2, is smooth, but marked with very fine striæ, decussating each other at right angles, as in the dermal bones of the Hylæosaurus (*Lign.* 208, *fig.* 1ᵃ.). These scutes differ from those of other recent and fossil Crocodilians, in a lateral conical projection, marked *a*, *figs.* 1, 2, *Lign.* 207, which fits into a depression on the under surface of the opposite angle of the adjoining plate; resembling, in this respect, the scales of the Lepidotus (see *Lign.* 196, p. 605). Numerous hexagonal and pentagonal scutes, articulated together by marginal sutures, also entered into the composition of the osseous dermal cuirass of this reptile, which must, therefore, have possessed a flexible, yet impenetrable, coat of armour, capable of affording protection against the attack of any assailant.

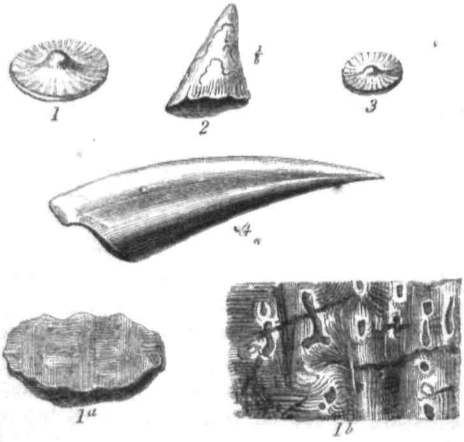
In the Oolite, the dermal bones of other slender-nosed Crocodilians (*Teleosaurus*) are occasionally met with; the outer surfaces of which are marked with small circular distinct pits; these scutes are thicker and more rectangular than those above described, and slightly overlapped each other laterally; they have no connecting process. In another species one half of the outer surface is smooth, proving that it was covered to that extent by the adjoining scute.*

Dermal Bones of the Hylæosaurus.—Elliptical and circular dermal scutes, having the under surface flat and the upper convex with a conical tubercle, were first noticed in the specimen of the *Hylæosaurus*, figured *Wond.* pl. iv.; and I have since discovered similar bones associated with other remains of that extraordinary reptile; reduced figures of two specimens are represented in *Lign.* 208, *figs.* 1, 3.

The structure of these bodies is very remarkable; upon closely inspecting the under side, and the surface exposed by a transverse fracture, very minute osseous spicula, de-

* A description of the dermal bones of British fossil reptiles is given in Brit. Assoc. Report for 1841, pp. 70, 79, &c.

cussating each other at right angles, are distinctly seen; as shown in *Lign.* 208, *fig.* 1^a. In *fig.* 1^b, a thin slice of the same, highly magnified, and viewed by transmitted light, displays medullary canals, with very fine lines radiating from them. The peculiar character of this organization consists in the disposition of the straight bony spicula; an appear-



LIGN. 208. DERMAL BONES OF REPTILES. *Tilgate Forest.*

Fig. 1, and 3.—Dermal bones of the HYLÆOSAURUS: $\frac{1}{3}$ *nat.*
1a.—The under surface of a fragment of a *dermal bone*, displaying fine spicula, decussating each other at right angles, and indicating a similar structure to that of the *Corium*, in which the bones were imbedded: *nat.*
1b.—A portion of the same, highly magnified, and viewed by transmitted light.
2.—HORN of IGUANODON: $\frac{1}{6}$ *nat.*
4.—A DORSAL SPINE of the HYLÆOSAURUS; the original is thirteen inches long.

ance which first attracted my attention when developing the original specimen of the Hylæosaurus (see *Geol. S. E.* p. 327), and led to the discovery of some perfect examples, which

otherwise would have been destroyed. This structure closely resembles that presented by the ligamentous fibres of the *corium*, or skin, and seems to have resulted from an ossified condition of the dermal integument. These bones vary from half an inch to three or four inches in diameter, and were disposed in one or more longitudinal series on each side the spine, diminishing in size as they approach the end of the tail.

DERMAL SPINES OF HYLÆOSAURUS. *Lign.* 208, *fig.* 4.—With the dermal bones above described there are associated in the first discovered specimen of the Hylæosaurus, flat, thin, angular, osseous plates, from three to seventeen inches in length; one of which is figured *Lign.* 208, *fig.* 4. The manner in which they are imbedded in the rocks, in connexion with other parts of the skeleton, is shown *Wond.* pl. iv. and *Geol. S. E.* pl. v. These very remarkable processes appeared to me to have formed part of a serrated fringe, which extended along the back of the reptile, analogous to that observable in certain living lizards (*Wond.* p. 436, *Lign.* 108); and were provisionally described as such in my first memoir on the Hylæosaurus. This conjecture has been substantiated by subsequent discoveries, and the true nature of the large, flat, angular spines, and the conical bones resembling the horn-cones of ruminants, which occur in the Wealden, is now established.*

HORN OF IGUANODON.—In this category may be placed the nasal tubercle or horn of a saurian, like that of the Iguana (*Lign.* 208, *fig.* 2; *Geol. S. E.* pl. iii.), found with the remains of the Iguanodon, and probably belonging to that colossal reptile (*Wond.* p. 431; and *Petrif.* p. 298). It is four inches in length and 3.2 inch by 2.1 inch in diameter at the base, which is of an irregular elliptical form. Several smaller specimens have recently been discovered.

* See *Fossils, Brit. Mus.* pp. 298, 320.

Examples of dermal scutes and spines, presenting modifications of form and structure distinct from those above described, have been brought to me from various localities of the Wealden; but, as in no instance a connexion with other parts of the skeleton could be traced, the particular reptiles to which they belonged cannot be ascertained.

We proceed to notice some of the principal genera of Fossil Reptiles, especially of those whose remains occur in the British strata; the arrangement of Professor Owen is adopted for the convenience of reference to the Brit. Assoc. Reports, 1839 and 1841, which should be consulted by the student who would acquire a knowledge of this department of Palæontology. The subject will be considered under the following heads; namely:—

I. *Enaliosaurians*, or Marine Reptiles; Ichthyosaurus and Plesiosaurus.

II. *Crocodilians;* Crocodile, Teleosaur, &c.

III. *Deinosaurians;* comprising the Iguanodon, Megalosaurus, Hylæosaurus, Pelorosaurus, &c.

IV. *Lacertians;* including the Mosasaurus, Rhyncosaurus, &c.

V. *Pterosaurians;* the Pterodactyles, or flying Reptiles.

VI. *Chelonians;* or Tortoises and Turtles.

VII. *Ophidians;* or Serpents.

VIII. *Batrachians;* or the Frog tribe; comprising the Labyrinthodonts.

I. ENALIOSAURIANS.—The extinct marine reptiles comprised in this order constitute two genera, which are characterized by essential modifications of osteological structure; they are named ICHTHYOSAURUS (*fish-lizard*), and PLESIOSAURUS (*akin to a lizard*). The general appearance of these beings is so well known, from the splendid collection of their fossil remains in the British Museum, and the numerous specimens in provincial and private collections, and by

various works, both scientific and popular, in which their structure and physiological relations are fully elucidated, that they must be familiar to every reader.*

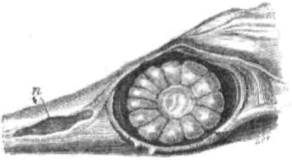
The living ICHTHYOSAURUS must have borne a resemblance to a Grampus or Porpoise, with four large flippers or paddles and a long tail, having a vertical caudal fin of moderate dimensions; the skin probably being naked and smooth, as in the Cetaceans. The PLESIOSAURUS presented a configuration still more extraordinary (*Wond.* p. 575). With a very small head, it possessed a neck of enormous length, a body of moderate size, with four paddles, resembling those of turtles, and a very short tail. They were both marine, air-breathing, cold-blooded, carnivorous, vertebrate animals; swarming in prodigious numbers during the secondary epochs, and particularly in the seas of the Liassic period (*Ly.* p. 277, figs. 310, 311). In both genera the construction of the skeleton presents many important variations from all known recent types; and should be carefully investigated by the student, who will find in the Reports of Professor Owen above referred to all the information that can be desired.†

It will suffice for our present purpose to point out a few important and obvious characters.

* *Bd.* vols. i. and ii. contain an admirable exposition of their habits and organization; and Brit. Assoc. Reports, 1839, 1841, elaborate osteological investigations of both genera. A folio-volume on these extinct Reptiles, with splendid lithographs, by Thomas Hawkins, Esq., cannot fail to delight the reader by its graphic descriptions and beautiful illustrations. See also the masterly paper on the Ichthyosaur and the Plesiosaur, by the Rev. W. D. Coneybeare, in the Geological Transactions, 1st series, vol. v. p. 559, *et seq.*

† The Penny Cyclopædia, Art. PLESIOSAURUS, contains an able abstract of these Reports; and in the *Fossils of the British Museum*, the student will find a full account of the discovery of the Ichthyosaur and Plesiosaur, and of the deposits in which they are chiefly found, as well as detailed descriptions of the most characteristic structures of the different species.

In the Ichthyosaurus, the nasal apertures or openings of the nostrils are not towards the snout, as in the Crocodile, but near the anterior angle of the orbit (see *Lign.* 209), approaching, in this respect, some of the recent lizards. The orbit is very large, and the sclerotic coat or capsule of the eye has in front an annular series of bony plates (*Bd.* pl. x. figs. 1, 3), which often occur in their natural position (*Lign.* 209). This structure is not possessed by fishes, but is analogous to that observable in the eyes of turtles, lizards, and many birds; as for example, in the owl and eagle: it



LIGN. 209. EYE OF ICHTHYOSAURUS. $\frac{1}{6}$ *nat.*

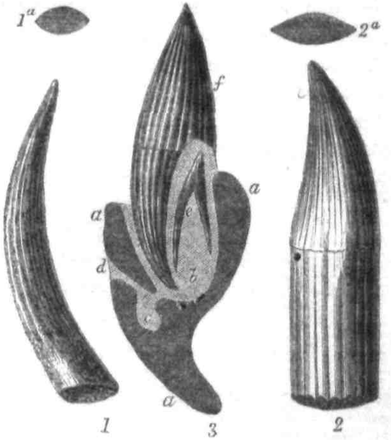
Lias. Lyme Regis.

Portion of the facial part of the skull of an Ichthyosaurus, showing the position of the nostril, and of the orbit with its circle of bony plates, forming the sclerotic coat of the eye.

n. The left nasal aperture.

confers on the eye additional power of adaptation and intensity of vision. The muzzle of the Ichthyosaurus is long and pointed; the lower jaw is formed of two branches, united anteriorly through nearly half their length; each branch is composed of six bones, as in the Crocodile and Lizards, but differently arranged than in those reptiles. The teeth are very numerous, amounting to nearly two hundred in some species, and are placed in a single row along the jaws, being implanted in a deep continuous groove (see *Bd.* pl. xi.). These teeth are of a pointed conical form, longitudinally striated, with an expanded base (*Lign.* 210). The new teeth are developed at the inner side of the base of the old, and grow up and displace them

(see *Lign.* 210). The microscopical structure of the teeth of the Ichthyosaurus is beautifully illustrated by Professor Owen (*Odontography*, p. 275, pl. lxiv.). The tooth consists of a pulp-cavity, surrounded by a body of dentine,



LIGN. 210. TEETH OF ICHTHYOSAURUS AND PLESIOSAURUS. *nat.*

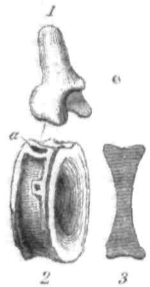
Lias. Somersetshire.

Fig. 1.—Tooth of Plesiosaurus.
1a. Transverse section of the lower part.
2.—Tooth of Ichthyosaurus.
2a. Transverse section of the middle of the tooth.
3.—Vertical section of part of lower jaw of Ichthyosaurus, with a tooth, illustrative of the mode of dentition.
a, *a*, *a*. Section of the lower jaw, showing the deep furrow *b*, in which the teeth are implanted.
c. The canal for the dental vessels.
d. Foramen for the passage of vessels to the outer integuments.
e. Germ of a successional tooth which has occasioned the absorption of the inner portion of the base of the mature tooth, *f*.

which is invested at the base by a thick layer of cement; and at the crown by a coat of enamel, also covered by a pellicle of cement; the pulp-cavity, in fully-formed teeth,

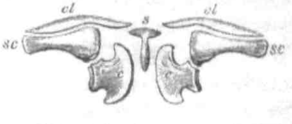
is more or less occupied by coarse bone. The chief peculiarity of this structure consists in the inflection of the cement into vertical folds at the base of the tooth, by which the marginal portion of the basal dentine is divided into a corresponding number of processes; producing, in a transverse section, the appearance represented in *Pl. VI. fig.* 9. This organization, as we have previously remarked, is similar to that observable in the teeth of the *Lepidosteus* (see p. 616), and of the extinct reptile, called *Labyrinthodon*, hereafter to be noticed.

The vertebræ (*Bd.* pl. xii.; and *Lign.* 211), of which there are upwards of one hundred and forty in the individuals of some species, are relatively very short in their antero-posterior diameter (*i.e.* from front to back); and deeply cupped on each articulating face, as in fishes. The annular part is not united to the body of the vertebra, as in mammals, nor connected by suture, as in Crocodiles, but terminates on each side in a compressed oval base, which fits into corresponding sockets placed on the boundary line of the spinal depression on the body (*Lign.* 210, 2[a]); thus completing the medullary canal (see *Bd.* pl. xii. fig. D, E.). Hence the collector may easily recognise the body of an Ichthyosaurian vertebra, by the pits or depressions on the sides of the spinal interspace. The first and second vertebræ are anchylosed together, and have additional subvertebral, wedge-shaped bones, which render this part of



LIGN. 211. VERTEBRA OF ICHTHYOSAURUS. $\frac{1}{3}$ *nat.*
Fig. 1.—Neural arch and spine.
2.—Body or centrum.
a.—Socket for the reception of the corresponding process of the neural arch.
3.—Vertical section of the centrum.

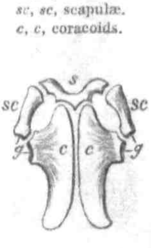
the column a fixed point of support.* (*Bd.* pl. xii. figs. 3, 6.) The form and arrangement of the bones that enter into the composition of the pectoral and pelvic arches, and of the paddles, are exemplified in *Bd.* pl. xii. ; and full osteological details are given in *Brit. Assoc. Rep.* 1839, p. 104. The characters of the several bones composing the pectoral arch of the Ichthyosaur will be readily understood from the accompanying illustration. The structure of the pectoral arch of the Plesiosaur is also shown in an accompanying Lignograph, for the sake of comparison. The bones of a fore-paddle of an Ichthyosaurus are represented (*Lign.* 214, *fig.* 1). In some species each paddle consists of nearly one hundred bones. These locomotive extremities are very analogous in their osteological construction to those of the Cetaceans, but they are connected with the trunk by means of the glenoid socket formed by the scapula and coracoid, which are firmly united to the sternum ; whereas in the Cetaceans the pectoral fin is only attached to a simple scapula, which is merely suspended in the muscles. This structure, together



Lign. 212. The bones composing the Pectoral Arch of Ichthyosaurus.

⅛ *nat.*

s, sternum.
cl, *cl*, clavicles.
sc, *sc*, scapulæ.
c, *c*, coracoids.



Lign. 213. The bones composing the Pectoral Arch of Plesiosaurus.

⅛ *nat.*

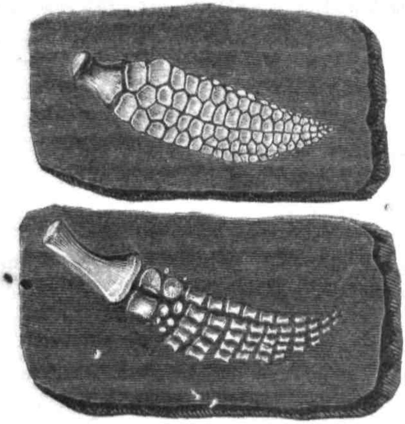
s, sternum.
sc, *sc*, scapulæ or omoplates.
c, *c*, coracoids.
g, *g*, the glenoid cavities or sockets for the head of the humerus or arm-bones.

* This structure was first demonstrated by Sir Philip Egerton. See Geol. Trans. 2d series, vol. v. p. 187, pl. xiv.

with the presence of a clavicle in the Ichthyosaurus (see *Lign.* 212), which is wanting in the Cetaceans,, indicates, in

1

2



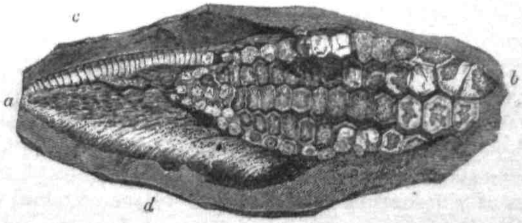
LIGN. 214. PADDLES OF ICHTHYOSAURUS AND PLESIOSAURUS. $\frac{1}{6}$ *nat size.*
Lias Shale. Lyme Regis.
Fig. 1.—Left fore-paddle of the Ichthyosaurus.
2.—Left fore-paddle of the Plesiosaurus.

the opinion of Professor Owen, that this marine fish-lizard was capable of some degree of locomotion on the land; and that it might have resorted to the shore to deposit its eggs, or, like the Crocodile, to sleep. From the frequent occurrence of a dislocation or abrupt bend of the vertebral series of the tail, at about one-third of its length from the end, supposed to have been produced by the weight of a large fin, during the progress of decomposition, and from the terminal caudal vertebræ being laterally compressed, it is inferred that the Ichthyosaurus had a vertical fin at the extremity of the tail, which would thus be rendered a powerful instrument of progressive motion.* From the appearance of the *Coprolites,*

* Geol. Trans. 2d ser. vol. v. p. 511, pl. xlii.

which occur abundantly with the skeletons of these animals, it is obvious that the intestinal canal in the Ichthyosaurus was furnished with spiral valves, as in the *Sharks;* and the comminuted bones and scales in the coprolites prove that fishes constituted the principal food of these marine reptiles.

The Ichthyosaurus has abdominal ribs (p. 656, note), as in the Crocodile, and it is therefore inferred that, if oviparous, it did not produce ova in such immense numbers as the Batrachians, &c. A specimen found by the late Mr. Channing Pearce renders it probable that the Ichthyosaurus may have been viviparous. A remarkably perfect adult Ichthyosaurus, examined by this gentleman, contained the bones of a fœtus (a few inches long) *in the cavity of the pelvis.* This specimen is in the collection of Mr. Pearce, at Bath. Remains or traces of the dermal integument have been discovered in some examples from the Lias of Barrow-on-Soar, Lyme Regis, Ilminster, and the neighbourhood of Tewkesbury.*



LIGN. 215. HINDER PADDLE OF AN ICHTHYOSAURUS (⅓ *nat.*): with the impression of its integuments. *Lias. Barrow-on-Soar.* (*From Geol. Trans. 2d ser. vol. vi. pl. xx.*)

INTEGUMENTS OF THE PADDLE.—The importance of carefully examining the surrounding stone before removing vegetable or animal remains from the matrix in which they

* See Mr. Coles's interesting paper on the Skin of the Ichthyosaurus, in the Quart. Journ. Geol. Soc. vol. ix. p. 79.

are imbedded, and which has so often been insisted upon in the preceding pages, is strikingly exemplified in the highly interesting example of the hinder paddle of an Ichthyosaurus (*I. communis*) discovered by Sir Philip Egerton. *Lign.* 215 is reduced from the exquisite representation of the specimen accompanying the original memoir by Prof. Owen on this fossil, in the Geological Transactions. The specimen consists of the phalangeal bones of a posterior paddle, with the impression of the soft parts or integuments in their natural position; *a*, marks the termination or distal extremity of the fin, consisting entirely of the softer integuments; these gradually widen and expand to receive the terminal rows of the phalangeal ossicles or bones, marked *b*. The upper border of this integumentary part of the paddle (*c*) is formed by a smooth, well-defined line, apparently a mere duplicature of integument. But the lower margin (*d*) exhibits the impressions of a series of rays, by which the fold of integument was supported; these rays bifurcate as they approach the margin of the fin, and were probably either cartilaginous, or composed of an albuminous horny tissue, like the marginal rays in the fins of Sharks. Dr. Buckland detected remains of the dermal integument of an Ichthyosaurus in a specimen from the Lias at Barrow-on-Soar (*Bd.* ii. p. 22, pl. x.); and in a fine skeleton with the four paddles (now in the British Museum), which I obtained from that locality, there were decided traces of the carbonized integuments around each paddle, but which were, unfortunately, chiselled away, in developing the bones, before I was aware of their true nature.

In Mr. Coles's paper, already referred to, the student has an instructive instance of the value of a careful examination of faint or obscure traces of organic matter accompanying these saurian remains, and how such an examination should be made. The Plate illustrative of the Memoir exhibits the minute, hooked, conical bodies, that form the dense felt-

like mass which the black film, frequently accompanying these fossil bones, appears to consist of, when seen under the microscope. To what extent this substance entered into the constitution of the integuments, or of the exact relation of these "setiform scales" to the surface or the interior of the skin, our present knowledge does not enable us to judge.

Plesiosaurus (*Bd.* pl. xvi.—xix.).—The animals of this genus present in their osteological structure a remarkable deviation from all known recent and fossil reptiles; uniting the characters of the head of a lizard, with the teeth of a crocodile, to a neck of inordinate length, with such modifications of the ribs, the pectoral and pelvic arches, and the paddles, as to justify the graphic simile of Professor Sedgwick, that the Plesiosaurus might be compared to a serpent threaded through the shell of a turtle.

The character which immediately strikes the observer, is the extraordinary length of the neck, and the relative smallness of the head. The neck, which in most animals is formed of but five vertebræ, and in the extremest recent example, the Swan, does not exceed twenty-four, is in the Plesiosaurus composed of from twenty to forty; and, in some species, is four times the length of the head, and equal to the entire length of the body and tail; while the length of the head (in *P. dolichodeirus*) is less than one-thirteenth of the entire skeleton. The skull resembles that of the crocodile in its general form, but is relatively smaller, and is more related to the lacertian type. The parietal bone is more triquetal than in the crocodiles; but the zygomatic bone is attached to its lower end. The breathing apertures are situated anterior to the orbits, on the highest part of the head. The lower jaw has the usual structure of the Saurians; but the dentary bone is greatly expanded anteriorly, and united in front (see *Bd.* pl. xix.). The teeth are implanted in separate sockets, as in the crocodile,

and there are from thirty to forty on each side the jaws. They are conical, slender, long, pointed, slightly recurved, and longitudinally grooved from the base upwards; having a long round fang. The pulp-cavity is long and single, surrounded by a body of firm dentine, covered on the crown with a layer of enamel, and at the base with cement (*Odont.* pl. lxxiv.). The dentition in the Plesiosauri differs from that of the Crocodiles, in the successional teeth emerging through distinct apertures on the inner side of the sockets of their predecessors, and not through the pulp-cavity. The vertebræ are relatively longer than in the Ichthyosaurus, and their articular faces are either flat, or slightly excavated towards the periphery, with a gentle convexity in the centre (*Foss. Til. For.* pl. ix. fig. 4).*

The caudal vertebræ have two distinct hæmapophyses, not united into a chevron bone.

The cervical ribs, or hatchet-bones, are attached by two articular facets to the bodies of the vertebræ, but with a very narrow space between; scarcely large enough even for the passage of the sympathetic nerve; and apparently not sufficient for the vertebral artery.

The *pectoral arch* is remarkable for the pair of elongated and broad coracoid bones (*Bd.* pl. xvii. and *Lign.* 213); indeed the coracoids attain their maximum of development in the Plesiosaurus. The *ribs*, which are very numerous, and extend throughout a great portion of the vertebral column, are connected, anteriorly, in the abdominal region, by several slender bones, called *costal arcs*, consisting of six or seven pieces to each pair of ribs; the Ichthyosaurus has a similar structure, but the arcs are composed of but five pieces. As these connecting bones are so constructed as to admit of a certain degree of gliding motion upon each other, it is inferred that, by this mechanism, considerable expan-

* For details, see Brit. Assoc. Rep. 1839, p. 50.

sion of the pulmonary cavities in these air-breathing marine reptiles was obtained (*Bd.* pl. xviii. fig. 3).

The paddles are composed of fewer and more slender bones than in the Ichthyosaurus, and must have been of a more elegant form, and possessed greater flexibility (*Lign.* 214, *fig.* 2). The wrist (*carpus*) consists of a double row of round ossicles, which are succeeded by five elongated metacarpal, and these by numerous slender and slightly-curved phalangeal bones.

Sixteen species of Plesiosaurus and ten of Ichthyosaurus have been discovered in the British strata, and nearly forty are now known; their geological range is from the Lias to the Chalk, inclusive.* Their remains are found most abundantly in the Lias and Oolite. I have collected many Plesiosaurian vertebræ in the Wealden, and in the Green Sand of Farringdon. No traces of Ichthyosauri have been observed in the Wealden; but vertebræ, and jaws with teeth, occur in the lower Chalk and Galt of Kent and Cambridgeshire.† On the Continent the remains of Enaliosaurians have also been discovered in the same formations.

PLIOSAURUS.—This name designates a gigantic extinct reptile, of which the upper and lower jaws, with teeth, considerable portions of the vertebral column, and many bones of the extremities have been discovered in the Kimmeridge clay of Oxfordshire, and are preserved in Dr. Buckland's museum. The teeth resemble those of the Plesiosaurus in their general aspect, being of a conical form, longitudinally grooved, and having a long fang; but they are readily distinguished by the subtrihedral form of the crown, produced

* See *Petrifactions*, for an account of the specimens in the British Museum.

† Brit. Assoc. Trans. 1845, Sect. p. 60. The Enaliosaurian bones and teeth found in the Cretaceous deposits of England have been fully described and illustrated by Prof. Owen, in Dixon's *Fossils of Sussex*, &c., and in his Monograph on the Fossil Reptiles of the Cretaceous Formation, Palæontographical Society, 1851.

by the smooth, flat, or slightly convex external surface; they approach in this respect the tooth of the Mosasaurus; from the latter, however, even fragments may be known by the presence of longitudinal ridges. The animal itself was an enormous marine reptile, allied to the Plesiosaurians, but more nearly related to the Crocodilians.*

II. CROCODILIANS.—The loricated, or mailed, Saurian reptiles, viz. the Alligators, Crocodiles, and Gavials, are well known as the largest living forms of cold-blooded oviparous quadrupeds.† No relics of any recent species have been observed in a fossil state; except that of the Gangetic Gavial, which has been found fossil in the Sub-Himalayas by Capt. Cantley and Dr. Falconer; but remains of Crocodilians of the existing generic type, having the spinal column composed of concavo-convex vertebræ (*i.e.* united to each other by a ball and socket-joint), the convexity being behind, or towards the tail, have been found in the London Clay at Hackney and the Isle of Sheppey, and in the eocene deposits on the coast of Western Sussex and Hants.‡ But the Crocodiles of the Wealden, Purbeck, Oolite, and Lias differ materially in their osteological characters from the recent species, particularly in the structure of the vertebral column; which in one genus is composed of concavo-convex vertebræ placed in a reversed position to those of the existing species, the ball or convexity being *anterior*, or directed forwards. In the other

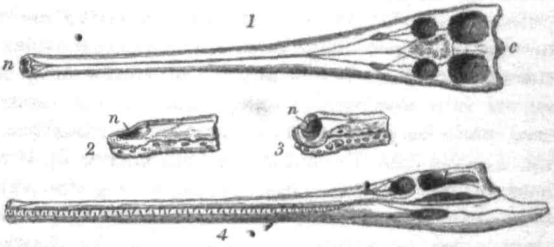
* Brit. Assoc. Rep. 1841, p. 60. Odont. pl. lxviii.

† A detailed and philosophical examination of the osteology of the recent Crocodilia has lately been given to the scientific world by Prof. Owen, in his Monograph on the Reptilia of the London Clay, published by the Palæontographical Society of London, 1850. A condensed notice, by Prof. Owen, of the dental apparatus of the Crocodilians, is to be found in the *Cyclop. Anat.* Art. TEETH.

‡ See Brit. Assoc. Rep. 1844, Sect. p. 50; and 1847, Sect. p. 65.

genera, both the articular faces of the vertebræ are either flat, or concave.* (*Geol. S. E.* p. 296.)

Vertebræ of two species of Crocodilians or Alligators have been found in the cretaceous Green Sand of the United States: these are of the true procœlian† type, as in the existing species; but they present peculiar characters in the modification of the apophyses.‡



LIGN. 216. SKULL AND JAWS OF TELEOSAURUS. ⅛ *nat.*

Lias. Whitby.

Fig. 1.—Upper view of the cranium of Teleosaurus.
c, occipital condyle.
t, *t*, temporal fossæ.
o, *o*, orbits.
n, nasal apertures.
2.—Muzzle or anterior extremity of the jaws of *Steneosaurus*.
3.—The same of Teleosaurus.
4.—Lateral view of the cranium and lower jaw of Teleosaurus.

With this exception, the Crocodilians with broad muzzles, as the Cayman and Alligator, have no representatives below the Tertiary formations; the *Crocodilia* of the Secondary deposits being all referable to the division having elongated beaks, like the recent Gavials (*Bd.* p. 250). The fossil Crocodiles of the latter type are arranged in two genera;

* Cuvier, Oss. Foss. tom. v. p. 153; on the fossil Crocodiles of Honfleur, which comprise both the types alluded to in the text.

† Procœlian, concave before: amphicœlian, concave at both ends platycœlian, flat in front and concave behind.

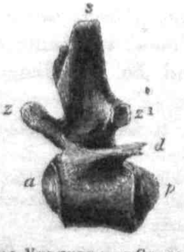
‡ See Quart. Geol. Journ. vol. v. p. 380, pl. x.

namely, TELEOSAURUS* (*Lign.* 216, *fig.* 3), in which the nasal apertures terminate in two orifices, (not blended into a single opening as in the recent species,) in front of the nose; and STENEOSAURUS (*Lign.* 216, *fig.* 2), in which the breathing canals end in two nearly semicircular vertical openings at the extremity of the muzzle. (See also *Bd.* pl. xxv.)

The British fossil species, most nearly related to the recent, occur in the Lower and Middle Eocene of the South-East of England. Two fine specimens of the skull of *Crocodilus toliapicus*, Cuvier and Owen (*C. Spenceri* of Dr. Buckland), have been found at Sheppey, as well as a skull of *C. champsoïdes* (Owen), and numerous vertebræ referable to each species. The eocene deposits of Hordwell Cliff have yielded the *Crocodilus Hastingsiæ*,† and the *Alli-*

* The skeleton of a recent Gavial, and that of a Teleosaur, are represented on one plate, for comparison, in Prof. Owen's Monograph, *loc. cit.*

† This fossil Crocodile supplies a good illustration of the biconvex body of the first caudal vertebra already described as peculiar to these loricated reptiles, see page 656; and I have subjoined *Lign.* 217 in illustration of this structure.



LIG. 217. FIRST CAUDAL VERTEBRA OF CROCODILUS HASTINGSIÆ. ½ *nat.*

Eocene. Hordwell Cliff.

s, spinous process, or neural spine.
z, anterior zygapophysis or oblique process.
z1, posterior zygapophysis.
d, left diapophysis, or transverse process.
a, *p*, body or centrum, convex at both ends.

gator Hantoniensis (*Petrif.* p. 467; and *Charlesworth's Geol. Journ.* pl. i.); and the remains of a Gavial (*Gavialis Dixoni*, Owen, in Dixon's *Foss. Suss.*) have been found at Bracklesham.*

In the strata of Tilgate Forest, associated with innumerable remains of reptiles of various kinds, teeth of the Crocodilian type, belonging to two genera, are not uncommon.† The first kind (*Suchosaurus*‡ *cultridens* of Prof. Owen) is a tooth about an inch in length, of a slender acuminated form, compressed laterally, and gently recurved, with a sharp edge in front and behind; resembling, in its general figure, the tooth of a Megalosaurus, with the serrations on the edges worn off (*Pl. VI. fig.* 7). The sides of the crown are marked with a few longitudinal grooves. Some biconcave vertebræ found in the same quarries, and characterized by the compressed wedge-shaped form of the centre (*Foss. Til. For.* pl. ix. fig. 11), are supposed by Professor Owen to belong to the same reptile as the teeth above described; but it is hazardous to pronounce on the identity of these detached teeth and bones, without more corroborative proof than has hitherto been obtained.

Swanage Crocodile. (*Goniopholis crassidens.*) *Petrif.* p. 170, *Lign.* 38.—Under this name, the second species of Crocodilian teeth will be considered; the discovery of a considerable portion of a skeleton of a reptile with teeth of this form (*Wond.* p. 416), in a quarry near Swanage,

* Most of these valuable fossils are in the British Museum. They are all described in detail and most elaborately illustrated in Prof. Owen's Monograph, already referred to.

† *Foss. South Downs*, p. 50. *Foss. Tilg. For.* p. 64; pl. v. figs. 1—3, 7. *Cuv. Oss. Foss.* tom. v. p. 161, pl. x. See also Owen's later examination of these remains, *Report Brit. Assoc.* 1841, p. 67; and *Cyclop. Anat.* Art. Teeth.

‡ Brit. Assoc. Rep. 1841, p. 68. *Sucho-saurus* is derived from *Suchus*, or *Suchis*, the name given by Strabo to the sacred crocodile of the Egyptians.

having disclosed some of the most important osteological characters of the original. These teeth are distinguished from the former by their cylindrical base, and rounded, obtuse, conical crowns (*Petrif.* p. 171): they somewhat resemble in form those of the Crocodile, but the crown is strongly marked with numerous, well-defined, longitudinal grooves and ridges; and there is a sharp ridge on the middle of each side. A small specimen, broken off at the base, is represented *Pl. VI. fig.* 5; it shows the smooth cylindrical base of the tooth, which is covered with cement, and the finely striated enamelled crown; some of the teeth are more than two inches in length, and one inch in diameter at the base (*Foss. Til. For.* pl. v. figs. 1, 2). I have found these teeth in numerous localities; they are always well preserved, with the ridges sharp, and have a high polish (*Geol. I. Wight*, p. 357, *Lign.* 30); a series of successional teeth may often be detected in the pulp-cavity (see *Wond.* p. 414). The detached teeth, and fragments of dermal bones (*Lign.* 207), which, from their constant occurrence with this species, I had been led to consider as belonging to the same reptile, were the only relics that had come under my observation, until the discovery of the Swanage specimen above-mentioned.* On the two corresponding slabs containing this fine fossil are imbedded many detached teeth; a portion of the left side of the lower jaw, with two teeth in place; ribs and numerous vertebræ, which are biconcave, and have an irregular medullary cavity in the centre of the body; chevron bones resembling those of the Crocodile; the bones of the pelvic arch, and some of those of the extremities. With these are the remains of the osseous dermal cuirass, consisting of numerous scutes (figured and described p. 657, *Lign.* 207), scattered at random among the other relics of the

* Now in the British Museum: see *Petrif.* p. 170. A lithograph of one of the slabs was given in the third edition of the *Wonders of Geology*, 1839.

skeleton; some having the inner, and others the external surface exposed; several of these bones are perfect, and exceed six inches in length, and two and a half in breadth. Numerous scales of a small Ganoid fish (*Lepidotus minor*), common in the Purbeck strata, are also intermingled with these remains. This reptile is named *Goniopholis crassidens*, by Professor Owen.*

Pœcilopleuron.—The remains of an allied genus of Crocodile, the *Pœcilopleuron Bucklandi* (of Deslongchamps), occur in the Oolite, near Caen, Normandy. This reptile, like the Goniopholis, had biconcave vertebræ, with a large medullary cavity in the middle of the centrum. The body of the vertebræ is contracted in the middle, the neural arch anchylosed, with no trace of suture, and with a thin spinous process, which is remarkable for its backward inclination. Vertebræ of this character also occur in the Wealden strata of Tilgate Forest and the Isle of Wight.†

Teleosaurus (*Bd.* pl. xxv.).—In the Oolite of England and the Continent, the remains of a genus of extinct reptiles, having, like the recent Gavial, long slender muzzles, have been discovered in several localities. These fossils consist of the osseous scutes of an imbricated dermal cuirass; of the cranium and jaws with teeth; of the vertebral column; and many other bones. The characters of the dermal scutes, and of the muzzle with its terminal nasal apertures, have already been described (p. 659, and p. 676). There are

* *Gonio-pholis:—angle-scute.* Brit. Assoc. Rep. 1841, p. 72. Both the slabs of the Swanage specimen are admirably arranged in the same case in the British Museum, with bones and scutes of this reptile from Tilgate Forest; there can be no doubt that the entire lower jaw of the Swanage reptile might have been obtained if the quarrymen had taken the precaution of examining the adjoining block of stone.

† Brit. Assoc. Rep. 1841, p. 84. *Foss. Til. For.* pl. ix. fig. 8, represents a caudal vertebra.

several species of *Teleosaurus*; a splendid specimen of *T. Chapmanni*, fifteen feet long, from the Lias-shale on the Yorkshire coast, is preserved in the Whitby Museum; and there are interesting examples in the British Museum.* Teleosaurian remains have been found in the Oolite at Stonesfield, and at Deddington, Oxfordshire; and Mr. C. Moore, of Ilminster, whose museum is rich with perfect Ichthyosaurs and Fishes from the Upper Lias of the neighbourhood, has been highly successful in developing some charming specimens of small Teleosaurs from out of the same deposit. In the Oolite of Caen, in Normandy, very fine specimens of *T. Cadomensis* have been discovered; and from these the illustrious Cuvier first determined the character and affinities of the original.† The British Oolite contains also the relics of a reptile with biconcave vertebræ, belonging to the genus *Steneosaurus*: the cranium with the jaws and teeth have been found in Kimmeridge clay, at Shotover (*Bd.* pl. xxv.).‡

From the Jura limestone at Monheim, in Franconia, the remains of a small Crocodilian reptile (*Teleosaurus priscus*), with a long slender muzzle, have been obtained. In a specimen§ from the former locality, the skull, jaws with teeth, the entire vertebral column, and many parts of the skeleton are preserved: the entire length is but three feet.

STREPTOSPONDYLUS, *Lign.* 206, *figs.* 5, 7.—Baron Cuvier in his celebrated work, "*Recherches sur les Ossemens Fossiles,*" has given an elaborate description of the remains of two kinds of slender-nosed Crocodilians, from the Kimmeridge clay of Honfleur, and the Oxford clay of Havre.

The specimens consist of the jaws with teeth, vertebræ,

* *Petrifactions*, p. 178. † Oss. Foss. tom. v. p. 127.

‡ Report Brit. Assoc. 1841, p. 82.

§ Now in the British Museum: see *Petrif.* p. 178, where a detailed description of this unique fossil is given. See also *Ossem. Foss.* tom. v. pl. vi.

and some bones of the extremities.* In one species, the vertebræ are biconcave; in the other, they are convexo-concave, and present a remarkable deviation from the recent Crocodilian type, namely, that they are placed in a reversed position,—the convex face of the vertebra being directed anteriorly, or towards the cranium, and the concavity posteriorly; the name of the genus, *Streptospondylus* (reversed-spine), denotes this peculiarity of structure. The bodies of three or four large convexo-concave cervical vertebræ, were discovered in the Tilgate strata many years since, and are described in my various works (*Geol. S. E.* p. 300); but no suspicion was then entertained of their belonging to this genus, although I had repeatedly compared them with the figures of the Honfleur crocodile,† the imperfect state of the processes obscuring their true characters. Professor Owen first detected the true character of these Wealden vertebræ, in a large cervical, six inches long (now in the British Museum), in which two oblique processes are preserved on the concave end of the bone, their flat, oblong, articular faces, are directed downwards and outwards,—a character which at once proves them to be the posterior pair, for the anterior oblique processes would be directed upwards and inwards.‡ Vertebræ of the same species occur

* Oss. Foss. tom. v. p. 143, pl viii. ix.

† Reduced figures of two of these vertebræ are given in *Lign.* 206, *figs.* 5 and 7, p. 653.

‡ Brit. Assoc. Rep. 1841, p. 92. The position of the articulating surfaces of the oblique processes (*zygapophyses*) in more perfect specimens, subsequently discovered in various localities of the Wealden, established the existence not only of a saurian allied to the Streptospondylus, but also of other reptiles whose spinal column was wholly or in part made up of vertebræ which were convex in front and concave behind, as in the cervicals and anterior dorsals of certain mammalia. Some of these fossil vertebræ Dr. Melville has referred, with great probability, to the cervical region of the Iguanodon (see *Petrif.* p. 259); others cannot at present be satisfactorily assigned to any known genus of reptiles.

in the Wealden of the Isle of Wight; and of another species in the Oolite at Chipping Norton, and in the Lias of Whitby.

A concavo-convex caudal vertebra, with the relations of which I am unacquainted, was found in the same quarry in Tilgate Forest; a reduced outline of this unique fossil is given in *Lign.* 206, *fig.* 1. The centrum is of a sub-cylindrical form, and the articular face in front is concave, and that behind, convex; with a chevron-bone that is anchylosed to the body of the vertebra, as in some of the caudals of the Mosasaurus, and terminates in an inferior spine (*f.*); the pair of anterior oblique processes remains; the neural spinous process is destroyed.

CETIOSAURUS.—From a considerable number of vertebræ and bones of the extremities of some gigantic aquatic reptiles, discovered in the Oolite in various places in Oxfordshire, Northamptonshire, and Yorkshire, the present genus was established; the name being intended to indicate a distant general resemblance of these extinct Saurians to the Cetaceans.* The vertebræ differ from those of the Iguanodon in having their articular faces of a sub-circular form, and the body relatively short; the anterior face is nearly flat, and the posterior concave, in the dorsal vertebræ; but in the caudal both faces are concave, and have a well-defined elevated margin, which gives the body a deeply excavated character, easily recognizable. Vertebræ of this kind were among my earliest discoveries in the strata of Tilgate Forest. (*Geol. S. E.* p. 282.) Some specimens are eight inches in the transverse diameter of the articular face, and but four and a half inches in the antero-posterior length of the body.† The original animals are supposed to have been of aquatic,

* Proc. Geol. Soc. vol. iii. p. 457.

† The osteological characters of these remains, and the physiological relations of the original animals, are described in *Brit. Assoc. Rep.* 1841, pp. 94—102.

and probably of marine habits, on the evidence of the sub-biconcave structure of the vertebræ and of the coarse cancellous tissue of the long bones, which are destitute of a medullary cavity. They must have rivalled the modern whales in bulk, for some specimens indicate a length of forty or fifty feet; they are supposed to have had web-feet, and a broad vertical tail.*

POLYPTYCHODON.† — The remains of another gigantic marine Saurian have been discovered in the Green Sand at Hythe, in Kent; they consist chiefly of the bones of the pelvis and hinder extremities.‡ The femur must have been nearly four feet in length. The long bones have a cancellated structure, without a medullary cavity; the outer surface is finely striated. Probably in a recent state the cells were filled with oil, as in the *Cetacea.* Neither the vertebræ nor the teeth of this reptile are known; but, provisionally, these remains have been referred to the same animal as that to which the large, conical, longitudinally ridged teeth belonged, which have been found in the Kentish Rag, at Maidstone, and in the Chalk of Sussex, and have been named *Polyptychodon continuus.*§ Teeth of *P. interruptus* are not unfrequent in the Cretaceous series; and a portion of the lower jaw of this species, from the Chalk of Kent, is in Mr. Toulmin Smith's collection.‖

* Brit. Assoc. Rep. 1841, p. 102.

† *Poly-ptych-odon;* many-wrinkle-tooth.

‡ *Geol. Proc.* vol. iii. p. 449. The bones from Hythe were presented by their discoverer, H. B. Makeson, Esq., to the British Museum. See *Petrifactions*, p. 200.

§ Owen's Monograph, Cretac. Reptilia, Pal. Soc. p. 47.

‖ Ibid. p. 55. See also Dixon's Foss. Suss. p. 378. Teeth of the Polyptychodon are figured in *Odontography*, pl. lxxii.

CHAPTER XVII.

FOSSIL REPTILES; COMPRISING THE DEINOSAURIANS, PTERODACTYLES, TURTLES, SERPENTS, AND BATRACHIANS.

III. DEINOSAURIANS.—The Order DEINOSAURIA (*fearfully-great lizards*) has been established for the reception of those extinct colossal reptiles, comprising the *Megalosaurus, Hylæosaurus, Iguanodon,* and *Pelorosaurus,* which, in their organization, present the transition from the Crocodilians to the Lacertians, and whose essential osteological characters Professor Owen has described as follow:—

"This group, which includes at least three well-established genera of Saurians, is characterized by a large sacrum, composed of five anchylosed vertebræ of unusual construction; by the height, breadth, and outward sculpture of the neural arch of the dorsal vertebræ; by the two-fold articulation of the ribs to the vertebræ, viz. at the anterior part of the spine by a head and tubercle, and along the rest of the trunk by a tubercle attached to the transverse process only; by broad, and sometimes complicated, coracoids, and long and slender clavicles; whereby Crocodilian characters of the vertebral column are combined with a Lacertian type of the pectoral arch. The dental organs also exhibit the same transitional or annectent characters, in a greater or lesser degree. The bones of the extremities are of large proportional size for Saurians; they are provided with large medullary cavities, and with well developed and unusual processes, and are terminated by metacarpal, metatarsal, and phalangeal bones, which, with the exception of the ungual phalanges, more or less resemble those of the heavy pachydermal Mammals, and attest, with the hollow long-bones, the terrestrial habits of the species.

"The combinations of such characters, some, as the sacral ones, altogether peculiar among Reptiles, others borrowed, as it were, from groups now distinct from each other, and all manifested by creatures far surpassing in size the largest of existing reptiles, will, it is presumed, be deemed sufficient ground for establishing a distinct

tribe or sub-order of Saurian Reptiles, for which I would propose the name of *Dinosauria*.

"Of this tribe the principal and best established genera are the *Megalosaurus*, the *Hylæosaurus*, and the *Iguanodon;* the gigantic Crocodile-lizards of the dry land; the peculiarities of the osteological structure of which distinguish them as clearly from the modern terrestrial and amphibious *Sauria*, as the opposite modifications for an aquatic life characterize the extinct *Enaliosauria*, or Marine Lizards."*

The elaborate investigation of the fossil remains of these stupendous beings, and the luminous exposition of their organization and physiological relations, embodied in the report to which the above extract is introductory, are among the most important contributions to Palæontology; and afford a striking example of the successful application of profound anatomical knowledge to the elucidation of the most marvellous epoch in the earth's physical history,—the *Age of Reptiles.*

From the great size of the bones of these reptiles, their remains have excited the curiosity even of the common observer; and although an exaggerated idea has been generally entertained of the magnitude of the original animals, yet, even when reduced to their natural proportions by the rigorous formula of the anatomist, applied to the accumulated relics which years of laborious research have exhumed from their rocky sepulchres and deposited in our museums, their dimensions are sufficiently stupendous to satisfy the most enthusiastic lover of the marvellous.

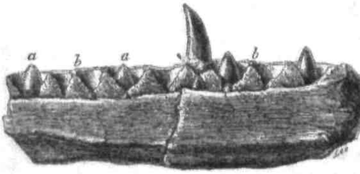
Let the reader visit the British Museum,† and after examining the largest thigh-bone of the Iguanodon, repair to the zoological gallery, and inspect the recent Crocodilian reptiles, some twenty-five or thirty feet in length; and observe that the fossil *bone* equals, if not surpasses, in size, the entire *thigh* of the largest of existing reptiles; then let him imagine this bone clothed with proportionate muscles

* Brit. Assoc. Rep. 1841, p. 103.

† See Fossils of the British Museum, p. 227.

and integuments, and reflect upon the enormous trunk which such limbs must have been destined to move and to sustain—and he will obtain a just notion of the appalling magnitude of the lizards which inhabited the country of the Iguanodon.

The general characters of the extinct reptiles comprised in the order *Deinosauria** must be known to the intelligent reader, from the various popular notices which have from time to time appeared; and their names have become as familiar as household words. I shall here restrict myself to a few general remarks on the form and structure of the teeth, and of some of the more important bones of the best known species of these great reptiles.†



LIGN. 218. MEGALOSAURUS BUCKLANDI. ½ *nat.*

Great Oolite. Stonesfield, Oxfordshire.

Portion of the left ramus of the lower jaw, containing several teeth in different stages of growth: inner aspect.

a, a. Crowns of successional teeth.
b, b. Transverse partitions of the tooth-sockets.

MEGALOSAURUS (*gigantic lizard*) BUCKLANDI. *Lign.* 218 and 219. *Bd.* pl. xxiii. *Wond.* p 421.—The oolitic flag-

* In the new edition of Pictet's *Paléontologie* (now in course of publication), two 4to. plates (xxiii. and xxiv.) are devoted to the illustration of the remains of these colossal reptiles.

† For further account of the Iguanodon, see *Petrif.* p. 224, &c.; of the Hylæosaurus, *ibid.* p. 314, &c.; of the Pelorosaurus, *ibid.* p. 330, &c.; of the Regnosaurus, *ibid.* p. 333, &c.; and of the Megalosaurus, *ibid.* p. 328, &c.

stone of Stonesfield, in Oxfordshire, has long been celebrated for the bones and teeth of a gigantic reptile, which Dr. Buckland first described by the name of *Megalosaurus*, in a highly interesting memoir (*Trans. Geol. Soc. sec. ser.* vol. i.), illustrated by figures of the teeth in a portion of the lower jaw, the sacrum, femur, and other bones. The remains of this reptile are also frequently discovered in the Wealden (see *Foss. Til. For.* p. 67, pl. ix. figs. 2, 6). The most important relic of this great carnivorous terrestrial lizard is a portion of the right ramus of the lower jaw, containing one perfect tooth, and the germs of several teeth (*Lign.* 218). The tooth of the Megalosaurus, (*Lign.* 219, and *Pl. VI. fig.* 7,) has a conical, laterally compressed crown, with the point recurved like a sabre, and the edges trenchant and finely serrated. The implantation of the teeth is very peculiar, and exhibits the dentition of the Crocodilians blended with that of the Lacertians. The jaw has an outer parapet, as in the true lizards (see *Lign.* 205), but the teeth are fixed in distinct sockets, formed by transverse partitions, that are attached to a mesial (*inner*) parapet, composed of a series of triangular osseous plates; the bases of the old teeth, and the germs of the new ones, being thus enclosed and concealed. The tooth is formed of a central body of dentine, the crown having a coating of enamel; and the whole an external investment of cement, which forms a thicker layer around the fang; the pulp-cavity is occupied by coarse bone, in the adult tooth. The microscopical examination shows the dentine to consist of very fine calcigerous tubes, $\frac{1}{28000}$th of an inch in diameter, without any admixture of medullary

LIGN. 219.
TOOTH OF THE MEGALOSAURUS BUCKLANDI.
(*Nat. size.*)
Wealden. Tilgate Forest.

canals, radiating from the pulp-cavity at right angles with the external surface of the tooth, and sending off numerous secondary branches; these ultimately dilate into, or inosculate with, a stratum of calcigerous cells that separates the dentine from the enamel.* A thin slice of a vertical section, viewed by transmitted light, is represented *Pl. VI. fig.* 7 *b*; showing the calcigerous tubes radiating from the centre, and terminating in the stratum of cells; this cellular structure is invested with a layer of enamel, and the latter with an external coat of cement, indicated by the dark outline.†

Four specimens of the sacrum, composed of five anchylosed vertebræ (*Foss. Til. For.* pl. xix. fig. 12), have been discovered; one of these is from Tilgate Forest. The femur of the Megalosaurus has two large rounded trochanters of nearly equal size, below the head of the bone; its shaft is subcylindrical, and slightly bowed.

This colossal carnivorous Saurian, whose length is estimated at thirty feet, appears to have been terrestrial, and an inhabitant of the same *terra incognita* as the Iguanodon: it probably preyed on the smaller reptiles, and the young of the Iguanodon, Crocodilians, &c.

HYLÆOSAURUS (*Wealden lizard*) OWENII. *Wond.* pl. iv. and p. 435; *Geol. S. E.* pl. v.).—In the summer of 1832, I obtained the interesting specimen which first demonstrated the existence of the remains of another extraordinary modification of Saurian organization in the Wealden. The circumstances which led to this discovery afford an instructive lesson to the young collector.

* Owen's *Odontography*, p. 271, which should be consulted for more minute details.

† To fully comprehend the minute structure of these and the other teeth figured in *Pl. VI.* Professor Owen's plates should be examined; the small scale necessarily adopted in the present work rendering it impossible to do justice to the subject.

Upon visiting a quarry in Tilgate Forest, which had yielded many organic remains, I perceived in some fragments of a large mass of stone, which had recently been broken up and thrown on the road-side, traces of numerous pieces of bone. I therefore collected all the recognisable portions of the block, and had them conveyed to my residence. The first step was to cement together those pieces that would admit of juxtaposition, and these were at length united into a block of stone five feet long, three wide, and about one foot thick. This was firmly fixed in a stout frame, to prevent the separation of the united portions during the process of chiselling. Guided by the indications which the sections visible on the edge afforded, a thin iron wedge was carefully driven in, about half an inch above the uppermost layer of bones, and a large slab was flaked off; the three dermal spines (*Wond.* pl. iv. 5) in the middle of the specimen were thus exposed, and shivered to pieces; some fragments adhered to the mass broken off, others to the block, and many were detached; every piece, however small, was collected, and those adhering to the slab were chiselled out; and the whole were then carefully replaced and cemented to the bones that remained imbedded in the large block. After an interval of some days, to allow of the firm cohesion of the cemented parts, the task was resumed, and the stone chiselled away, until some portion of the large bones of the pectoral arch (*Wond.* pl. iv. 7) were observed. The specimen was at length brought to the state in which it now appears (in the British Museum*); but during the progress of its development, which occupied many weeks, it was repeatedly necessary to suspend the work, and unite displaced fragments of bone, and resume the task after their consolidation. The plate in the *Geol. S. E.* conveys a good idea of the original.

The specimen consists of a part of the spinal column, composed of seven dorsal and three or four cervical vertebræ, almost in their natural juxtaposition, with obscure indications of a part of the base of the skull; eleven ribs; the bones of the pectoral arch (two *coracoids* and two *scapulæ*); with numerous dermal bones and spines. A second specimen of this reptile was found near Bolney, in Sussex; and like the former, it was, unfortunately, almost wholly destroyed by the labourers; but I obtained many bones, some of which are perfect, and indicate an animal of consi-

* See *Fossils, Brit. Mus.* p. 139, &c.

derable magnitude : a *scapula*, nineteen inches long, an arm-bone or *humerus*, numerous ribs, bones of the phalanges, &c. A fine series of twenty-six caudal vertebræ, having a total length of nearly six feet, with chevron bones and dermal spines, was discovered in 1837, in Tilgate Forest.* A few detached bones are the only other relics of this reptile that have come under my observation.† The osteological characters presented by these remains afford another example of the blending of the Crocodilian with the Lacertian type of structure; for we have in the pectoral arch the scapula or omoplate of a crocodile associated with the coracoid of a lizard. Another remarkable feature in these fossils is the presence of the large angular bones or spines (described p. 660, figured *Lign.* 208), which, there is reason to infer, constituted a serrated crest along the middle of the back; and the numerous small oval dermal bones, which appear to have been arranged in longitudinal series along each side of the dorsal fringe. (*Geol. S. E.* p. 323.)

The vertebræ, ribs, and other parts of the skeleton found in these specimens also present modifications of structure of great interest.‡ No specimens of teeth have been found associated with the remains of the Hylæosaurus, in such manner as to afford unequivocal proof of their belonging to that animal. But in the same quarries, teeth, decidedly of the Lacertian structure, are occasionally found, and may with some probability be referred to that reptile. These teeth (see *Pl. VI. fig.* 6ᵃ.) are about $1\frac{1}{4}$ inch in length, and commence at the base with a cylindrical shank, which gradually enlarges into a crown of an obtuse lanceolate form,

* See *Fossils, Brit. Mus.* p. 323.

† See "Memoir on the Remains of the Iguanodon, Hylæosaurus, and other Saurian Reptiles," by the Author, in *Philosophical Transactions* for 1841, Part II.

‡ See Report, Brit. Assoc. 1841, pp. 111—120. Phil. Trans. 1841, pp. 141—144, pl. x.

convex in front, hollowed behind, and terminating in a rounded obtusely angular apex, the margins of which are generally more or less worn.* The crown is solid, but the fang encloses a small pulp-cavity; the surface is enamelled, and covered with very fine longitudinal striæ; the base in every specimen appears broken transversely, as if it had been anchylosed to the jaw, or to the base of a socket. The fang never presents an appearance of lateral adhesion, as if belonging to a Pleurodont lizard. Sections of these teeth expose a simple, central, medullary canal, the upper part of which is generally filled with the ossified remains of the pulp; and this is surrounded by a body of firm dentine, with extremely minute calcigerous tubes radiating from the centre to the periphery of the tooth, which is invested with a relatively thick coat of enamel, in which no structure is apparent. *Pl. VI. fig.* 6^b represents a small portion of a vertical slice, highly magnified and viewed by transmitted light. The reference of these dental organs to the Hylæosaurus must not, however, be considered as conclusive, until confirmed by the discovery of the teeth attached to the jaw, in connexion with other parts of the skeleton. The locomotive organs of the Hylæosaurus are but imperfectly known; a perfect humerus, one phalangeal bone, and fragments of the fibula (the small bone of the leg) are the only bones hitherto observed. The length of this reptile, which was probably terrestrial and herbivorous, may be estimated at from twenty to thirty feet.

IGUANODON. *Ligns.* 219 to 226; *Wond.* pl. ii. iii., and pp. 422, &c.—Soon after my first discovery of the remains of vertebrated animals in the strata of Tilgate Forest, some teeth of a very remarkable character particularly engaged my attention, from their dissimilarity to any that had pre-

* Rep. Brit. Assoc. 1841, p. 118. Geol. S. E. England, pl. ii. figs. 2, 4. Phil. Trans. 1841, p. 144, pl. vi. figs. 9, 10, 11.

viously come under my notice.* Attention having been directed to these interesting fossils, examples were soon discovered of teeth in various conditions, from the sharp, unused tooth of the young reptile, to the obtuse, worn-out crown of the adult. From the resemblance of the perfect teeth to those of the Iguana (*Lign.* 205, p. 649), a land lizard of the West Indies, I proposed the name of *Iguanodon* (signifying an animal with teeth like those of the Iguana) for the extinct reptile to which they belonged. The numerous bones and teeth subsequently exhumed from the strata of Tilgate Forest and other localities in the Wealden of Sussex and of the Isle of Wight, and the considerable portion of the skeleton of an individual discovered by Mr. Bensted in the Kentish Rag, have supplied the data upon which our present knowledge of the characters of the original is based.

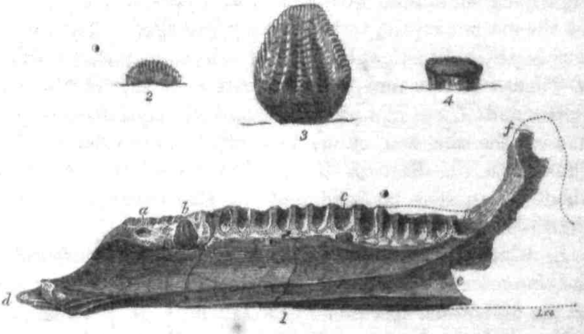
In *Wond.* pp. 422—435, a brief account will be found of the character of the teeth, horn, femur, vertebræ, &c., and of the Maidstone specimen† (*Pl. III.*).

The "Geology of the South-east of England" contains accurate figures of the long bones of the leg (*Geol. S. E.* pl. ii), femur, clavicles (*Geol. S. E.* pl. iv.), tympanic bone (*Geol. S. E.* pl. ii.), horn and ungual bone (*Geol. S. E.* pl. iii.). In the "Fossils of Tilgate Forest," there are fifteen quarto plates devoted to the illustration of the bones and teeth of the Iguanodon and other Wealden reptiles. The osteological structure is fully detailed in *Rep. Brit. Assoc.*

* These are described in *Foss. South D.* 1822, p. 54, under the head "*Teeth and bones of unknown animals.*" This was the earliest published notice of the fossils of the Wealden; it contains also a description of a tooth of the Megalosaurus (p. 55, No. 42).

† In a Monograph on the Reptiles of the Cretaceous Deposits of England, published by the Palæontographical Society, Professor Owen has lately figured anew and described in detail this most valuable fossil skeleton; to which description are appended the Professor's latest views on the structure of the teeth of this reptile.

1841, pp. 120—144. A general notice of the principal bones of the Iguanodon, with plates, will be found in *Phil. Trans.* 1841, pp. 131—151; and in *Petrif.* chap. iii. the author has given a detailed account of the most important specimens, both in the British Museum and in his own collection, together with a résumé of the palæontology and geology of the Wealden district.



LIGN. 220. IGUANODON MANTELLI. ½ *nat. size.*

Wealden. Tilgate Forest.

The right ramus of the Lower Jaw:* discovered in 1848, by Captain Lambart Brickenden, F.G.S.

Fig. 1.—The inner aspect, showing three teeth, and the sockets of eighteen.

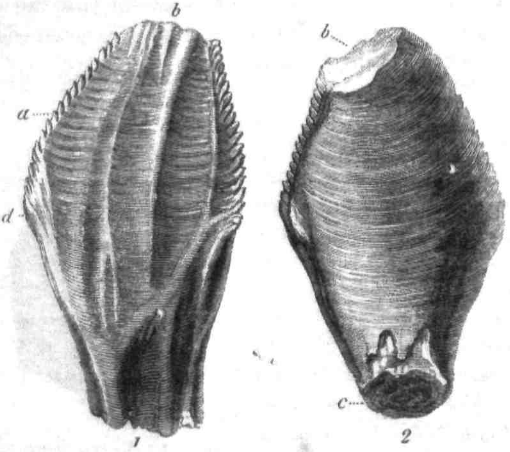
- *a.* Germ of a tooth.
- *b.* Perfect crown of a successional tooth.
- *c.* Remains of a successional tooth, the upper part having been broken off.
- *d.* The symphysial extremity of the jaw.
- *e.* The opercular furrow.
- *f.* The coronoid process.

2, 3, and 4, the teeth *a*, *b*, and *c*, in fig. 1, represented on a larger scale.

JAW AND TEETH OF THE IGUANODON. *Ligns.* 219—223.—Although the form and structure of the cranium are unknown, yet the half of a lower jaw, discovered in Sussex

* For the outer aspect, and a restoration of the whole jaw, see *Petrif.* pp. 247 and 249.

by Capt. L. Brickenden,* and a fragment of an upper jaw, found some years since,† enable us to form a tolerably perfect



LIGN. 221. LOWER TOOTH OF THE IGUANODON: *nat. size. Wealden. Tilgate Forest.*

The apex slightly worn.

Fig. 1.—Inner aspect, showing the longitudinal ridges, and denticulated margins of the crown of the tooth.

2.—View of the outer surface of the tooth.

a. The denticulated margin.

b. The apex of the crown, worn by use; *b.* fig. 2, shows the oblique smooth surface produced by mastication.

c. A transverse fracture of the fang, showing a section of the medullary cavity occupied by the ossified remains of the pulp.

d. Marks the inferior limit of the denticulated margin; if a line were carried horizontally from *d*, across the tooth, the under figure would represent a tooth worn down below the denticulations, and deprived of its peculiar dental characters; in this latter state the tooth somewhat resembles an incisor of a Rhinoceros (see *Ligns.* 222, 223; and *Petrif. Lign.* 48).

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* Figured and described in the *Phil. Trans.* 1848, p. 188, pl. xvi. xvii.

† Both specimens are fully described in *Petrif.* pp. 242, *et seq.*

idea of the structure and functions of the dental organs of the Iguanodon. The unused tooth of this reptile is characterized by the prismatic form of the crown, the presence of from two to four longitudinal ridges on its enamelled face, the denticulated margins (*Lign.* 221, *a*), and finely serrated edge of the summit, as seen in *Lign.* 220, *fig.* 3. The shank or fang of the tooth (*Ligns.* 221, 223, *fig.* 2) is subcylindrical, slightly curved, and tapers to a point. The inner surface of the crown in the lower teeth, and the outer surface in the upper, are covered with a thick layer of enamel, but the opposite face of the crown and the sides have but a thin coating of this substance. The teeth of the upper jaw (*Lign.* 222) are curved in the opposite direction to those of the lower, and have the convexity external, and the concavity internal. Thus the upper and lower molars were related to each other nearly as in the Ruminants; the outer aspect below corresponding to the inner above (see *Petrif. Lign.* 56, p. 254). The specimens met with have almost always the apex of the crown more or less worn down by use* (see *Lign.* 223), and presenting an oblique, triangular, smooth surface, as in the fine large specimen figured in *Lign.* 221, which was found

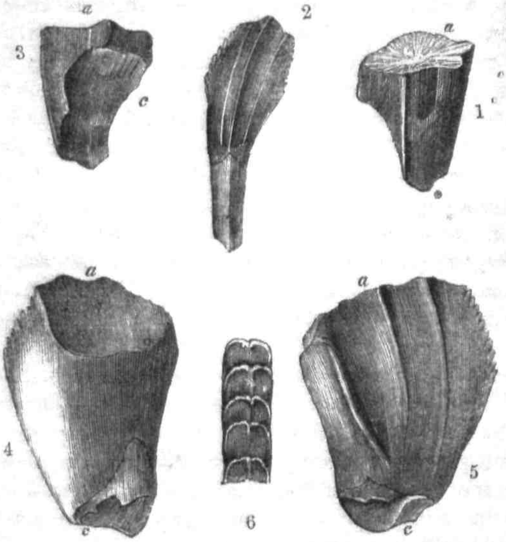
LIGN. 222. UPPER TOOTH OF THE IGUANODON: *nat. size.*

Wealden. Brook Bay, Isle of Wight.

The crown is worn down to an oblique smooth surface, and the fang is absorbed.

* Plates iv. and xvii. in the "*Fossils of Tilgate Forest*," contain representations of upwards of thirty specimens of teeth in various states of development and detrition.

imbedded in the trunk of a Clathraria, as if it had snapped off while the animal was in the act of gnawing the tough



LIGN. 223. TEETH OF IGUANODON. *Wealden. Tilgate Forest.*

Fig. 1.—Outer aspect of an upper tooth (in a reversed position), worn flat, and with the fang absorbed; fig. 3, inner aspect of the same tooth.

a, a. Flat grinding surface, produced by mastication when all the thickly enamelled portion of the crown is worn away.

c. Cavity produced by the pressure of a new tooth.

2.—Lower tooth of a young animal, slightly worn: inner aspect.

4.—Outer surface of a lower tooth of an adult; and fig. 5, inner surface of the same.

a, a. The hard cutting edge of the oblique surface worn by mastication.

c. Indentation produced by the pressure of a successional tooth.

6.—Edge view of the serration on fig. 5; magnified.

stem. The denticulated margins are well developed; in *fig.* 1, they appear as simple serrations; but viewed late-

rally, they are seen to be formed by a series of denticulated plates (*Lign.* 223, *fig.* 6). The crown of a tooth of a young animal, worn at the summit, and presenting but three longitudinal ridges, is represented *Pl. VI. fig.* 4[a]. The microscopical structure consists of a simple pulp-cavity in the centre of a body of dentine permeated by calcigerous tubes, but with this peculiar modification, that the dentine is traversed by vascular canals, radiating at definite intervals from the pulp-cavity nearly to the periphery of the tooth, and running parallel with the calcigerous tubes; thus constituting a softer and coarser dentine than in the other reptiles, and resembling that which characterizes the teeth of some of the herbivorous mammals.* The crown of the tooth is covered with a layer of enamel, which is thickest on the external surface; and the fang is invested with cement. The structure here described is shown in *Pl. VI.*; *fig.* 4[b], a vertical, and *fig.* 4[c], a transverse section of a tooth, seen by transmitted light, with a high magnifying power. The calcigerous tubes are $\frac{1}{25000}$th of an inch in diameter. Sections of the teeth of the Iguanodon are beautiful objects under the microscope, for the medullary canals are generally of a deep yellowish brown colour.

The dentine is less vascular, and therefore hardest, on that side of the crown which has the thicker coat of enamel; hence the tooth wears away faster on one side than on the other, and an oblique grinding surface, with a sharp edge of enamel, is maintained until the crown is worn away. The internal structure of the teeth of the Iguanodon is thus in perfect accordance with their external configuration, and must have been admirably adapted, in every stage, for the laceration and comminution of the tough vegetable sub-

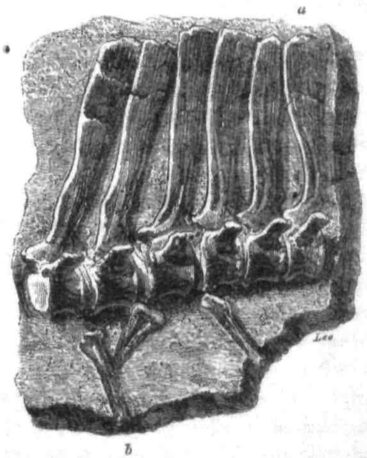
* Tomes on the Microscopic Structure of the Tooth of the Iguanodon, *Petrif.* pp. 239, 240. See also Owen's *Odontography*, p. 249, and pl. lxxi.; and *Cycl. Anat.* Art. TEETH.

stances which, there is every reason to conclude, constituted the food of this colossal oviparous quadruped.

VERTEBRÆ OF THE IGUANODON,* *Lign.* 206, p. 653 ; *Lign.* 224.—The remains of the vertebral column of the Iguanodon, consisting generally of broken and water-worn dorsal and caudal vertebræ, deprived of their processes and reduced to the state of the specimens represented *Lign.* 206, *figs.* 6 and 8, are so abundant in some of the Wealden strata, that a short account of their characters may be useful. A reference to *Lign.* 206, and its description, will render the following remarks intelligible to the general reader. The vertebræ of the Iguanodon are distinguishable from those of other reptiles which occur in the same strata by the following peculiarities, which the figure of a perfect specimen of a caudal vertebra (*Lign.* 206, *fig.* 3) will serve to illustrate. The body, or centrum, is either flat or somewhat depressed on both articular faces ; its sides are nearly flat, or somewhat convex, vertically (as in *fig.* 3), and slightly concave lengthwise, or from front to back : in some examples, the body is more contracted towards the inferior surface, as in *fig.* 6 ; and in the vertebræ, near the middle of the tail, the sides are compressed, so as to give an angular contour and somewhat vertical elongation to the face, as in *fig.* 4 ; but in the dorsal vertebræ, the articular faces are nearly circular, but somewhat higher than wide. In the caudal vertebræ, the inferior angles of the body are truncated (*w*, *figs.* 3, 4), and present an oblique, smooth face, to articulate with the chevron bone (*fig.* 3, *f*). The annular part is united to the body by suture (*fig.* 3, *o*), and anchylosed in the dorsal vertebræ ; and in these bones the neural

* A detailed account of the elements of the spinal column of the Iguanodon, and remarks on various fossil vertebræ, the relations of which with the Iguanodon have been considered doubtful, will be found in *Petrif.* pp. 256–279.

arch is very high, and greatly expanded, and its bases extend transversely inwards, and join each other below the spinal canal, forming a ring, or bony channel, to contain the spinal chord.* "The transverse processes are straight, and very long in the vertebræ from the middle of the trunk, indicating a considerable expanse of the abdominal cavity, adapted for the lodgment of the capacious viscera of



LIGN. 224. SIX CAUDAL VERTEBRÆ OF THE IGUANODON. $\frac{1}{12}$ *nat. size.*
Wealden. Tilgate Forest.

a, a. Spinous processes (*neurapophyses*), from 13 to 15½ inches in height.
b, b. Three displaced chevron bones (*hæmapophyses*), imbedded in the stone near their original position at the junction of the bodies of the vertebræ.
c. Anterior articular face of a vertebra.

a herbivorous quadruped." (*Owen.*) The spinous processes (*Lign* 206, *fig.* 3, *d*) are large and of great height in the anterior caudal vertebræ, *Lign.* 224 ; and here the

* See also lithographs of dorsal and caudal vertebræ from the Kentish Rag ; Owen's *Monog. Cret. Rept.* (Pal. Soc.) 1851.

chevrons, or hæmapophyses (*Lign.* 224, *b*, and *Lign.* 206, *fig.* 2, and *fig.* 3, *f*), are also of considerable length; the bases of the latter are always united (*Lign.* 206, *fig.* 2, *g*), and often blended, so as to form but one face for articulation with the truncated inferior angles of the body of the vertebræ, leaving a vertically elongated channel for the passage of the large blood-vessels of the tail. The external surface of the vertebræ of the Iguanodon is more or less marked with fine longitudinal striæ; those of the Megalosaurus have a smoother and more polished surface.*

BONES OF THE EXTREMITIES. *Ligns.* 225 and 226.—The thigh-bone (*femur*), both bones of the leg (*tibia* and *fibula*), and many of the metatarsal and phalangeal bones have been discovered; the osteology of the hinder extremity is, therefore, almost perfect. The thigh-bone (*Lign.* 225; and *Petrif.* p. 292,) is of a very remarkable character, having a closer resemblance to the femur of a huge mammalian, than to that of a reptile.† Several perfect specimens have been discovered, as well as the associated bones of the leg (*Petrif.* p. 293, *Lign.* 62); but the first fragment that came under my notice, was the middle portion of the shaft of a femur of enormous size, and of an irregular quadrangular form; and so shapeless and unintelligible it then appeared, that several years elapsed before its real nature was determined. (*Foss. Tilg. For.* pl. xviii.)

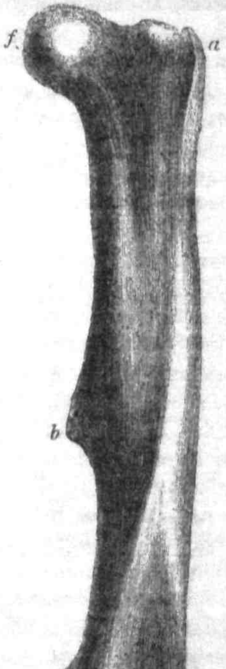
An entire thigh-bone of an adult Iguanodon, from the Weald clay in the west of Sussex, measured three feet eight inches in length,‡ and thirty-five inches in circumference at the condyles; and I have a femur of a very young animal,

* See Rep. Brit. Assoc. 1841, pp. 125—133, where an elaborate investigation of the vertebræ of the Iguanodon is given by Professor Owen.

† See Cuvier's *Ossem. Foss.* vol. ii. p. 36.

‡ The average length of the adult femur is estimated at about four feet five inches.

that is but five inches long. The form of the thigh-bone is so peculiar, that fragments may easily be recognised. The head of the femur (*Lign.* 225, *f*,) is hemispherical, and projects inwards; there is no appearance of a *ligamentum teres*; a flattened process or trochanter (*Lign.* 225, *a*,) forms the external boundary of the neck of the bone, from which it is separated by a deep and narrow vertical fissure; the shaft is of a sub-quadrangular shape, and a slightly elevated ridge, produced by the union of two broad, flat, longitudinal surfaces, extends down the middle of the anterior face, and, diverging towards the inner condyle, gradually disappears. The bone terminates below in two large condyles, separated in front and behind by a deep, narrow cleft, or groove (*Lign.* 225, *e*). Near the middle of the inner edge of the shaft, there is a compressed ridge, with an angular projection, or trochanter. Thus the upper part of the femur may be known by the presence of the flattened, or laterally compressed trochanter; and if that process



LIGN. 225. LEFT FEMUR OF THE IGUANODON. $\frac{1}{10}$ *nat. size.*
Anterior aspect.
Wealden. Brook Bay, Isle of Wight.

a. Outer trochanter.
b. Median trochanter.
c. Inner condyle.
d. Outer condyle.
e. Anterior infra-condyloid fissure.
f. Head of the femur.

be wanting, a fractured surface indicating its position may be detected; the middle of the shaft is characterized by its broad angular faces, and the inner submedian trochanter: the condyloid or inferior extremity of the bone may be distinguished by the deep groove between the condyles, both in front and behind.

The arm-bone (*humerus*) of the Iguanodon has been discovered in the Wealden of the Isle of Wight by Mr. Fowlstone; it is figured and described in *Petrif.* p. 286. The humerus is also present in the Maidstone specimen* of Iguanodon, before referred to at page 692: in pl. ii. of *Wond.* this bone is termed the *radius*. The humerus of this reptile is much smaller than the femur; in the Maidstone specimen the former is about 20 inches, and the latter about 33 inches in length.

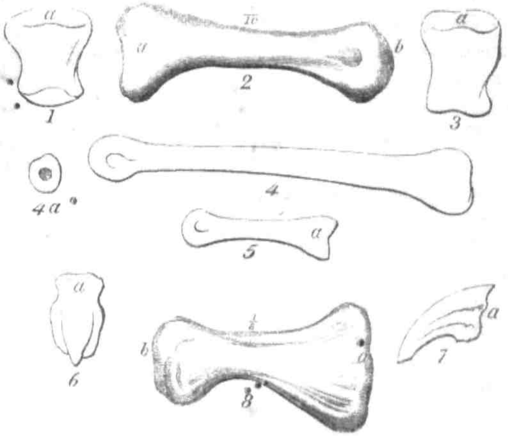
As separate bones of the feet of the Iguanodon, for example, *metacarpals*, *metatarsals*, *phalangeals*, and *unguals*, often occur in the strata of the Wealden, figures of several specimens, on a reduced scale, are introduced in *Lign.* 226, and may enable the student to identify those he may meet with in his researches.† The ungual phalanges, or claw-bones, which were invested with the nail, are sometimes found of an enormous size; from a quarry near Horsham, Mr. Holmes obtained specimens more than five inches long, and three inches wide at the articular extremity.

LENGTH OF THE IGUANODON.—The length of the united head and trunk, according to my estimate in *Geol. S. E.* p. 316, is seventeen feet and a half; by Professor Owen's estimate it is reduced to fifteen feet;‡ a difference of no

* The two bones marked "6" in pl. ii. *Wond.* and in *Lign.* 65, *Petrif.* (one of which is figured in outline in *Lign.* 226, *fig.* 4,) regarded by Prof. Owen as the *radius* and *ulna* (the two bones of the fore-arm): the author's reasons for regarding these bones as *metacarpals* are given in full at p. 289, *Petrif.*

† See Rep. Brit. Assoc. 1841, pp. 137—142. ‡ Ibid. p. 144.

importance in such merely approximative calculations, particularly when the form of the cranium is unknown.*



LIGN. 226. BONES OF THE FEET AND CLAWS OF THE IGUANODON.
Wealden. Tilgate Forest.
(*See Wond.* pl. iii.)

Fig. 1.—Metatarsal: original 6 inches long: upper surface.
2.—Metacarpal bone.
3.—Under surface of fig. 1.
4.—A phalangeal bone of the fore-foot: the original 14 inches long.
4*a*.—A transverse section of the same, showing the medullary cavity.
5.—One of the second row of phalangeal bones of the fore-foot.
6.—View from above of one of the claw-bones of the hind-foot: $\frac{1}{6}$ *nat.*
7.—Profile of claw-bone of fore-foot:† $\frac{1}{2}$ *nat.*
8.—Metatarsal, or bone of the hind-foot: $\frac{1}{8}$ *nat.*
a. Denotes the *proximal* articulation, or that nearest the trunk.
b. The *distal*, or extremity most distant from the trunk.

The estimated extent of the tail has been subject to variation. My early estimate of its length gave rise to the

* The more recently discovered specimen of lower-jaw, already referred to, page 693, indicates a length of between three and four feet for the entire jaw, *Petrif.* p. 249.

† This bone is conjecturally referred by Prof. Owen to the Megalosaurus.

idea of this reptile having attained seventy feet in length. Professor Owen, however, considered that the abbreviated character of the anterior caudal vertebræ indicated a far less extent of tail, which the Professor estimated at thirteen feet; this opinion, from the evidence then before us, seemed well founded, but from evidence since afforded by a series of eleven caudal vertebræ, belonging to the middle region of the tail, that have been lately discovered, (*Petrif.* p. 312,) it is not at all improbable, that, instead of all the caudal vertebræ being abbreviated, these elements of the tail were elongated as in the corresponding part of the skeleton of the Iguana, and that the largest Iguanodons may have attained a length of from sixty to seventy feet.

The author's physiological inferences as to the structure and economy of the Iguanodon, deduced from the study of the osseous remains of this singular creature, especially the lately discovered remains of the jaw-bones, are given in full at pp. 307—313 *Petrif.* or *Foss. Brit. Mus.*: and at pp. 335—338, *ibid.* may be found some general remarks on the physical geography and the nature of the fauna and flora of the country inhabited by these stupendous reptiles, whose remains are so characteristic of the Wealden rocks.

JAW OF THE REGNOSAURUS (*Petrif.* p. 333).—A portion of the right ramus, or side, of the lower jaw of this reptile was discovered in a block of sandstone from Tilgate Forest. It consists of a fragment, six inches long, of the dentary bones, with a small portion of the opercular; and it contains the fangs of fifteen teeth, which are closely and evenly set in a regular series, and imbedded laterally in grooves, or sockets, in the dentary bone; there are three or four sockets of successional teeth on the inner side of the bases of the old teeth. (*Phil. Trans.* 1841, pl. v. figs. 1, 2.) Unfortunately, all the crowns of the teeth are wanting. The outer parapet of the dentary piece is entire, and its

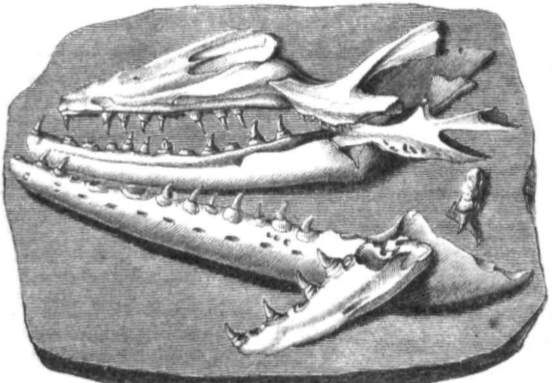
upper margin is finely crenated. All the fangs of the teeth are exposed, but there are traces of a thin inner wall, indicating the probability that, as in the Megalosaurus, the teeth were supported medially by an osseous plate, and were implanted in distinct sockets.* In my memoir on this fossil jaw in the *Phil. Trans.* (1841, p. 131), I referred it to the genus Iguanodon; but subsequent observations have led me to conclude that it is generically distinct; and in my Memoir on the Jaw of the Iguanodon, in *Phil. Trans.* 1848 (p. 183), I have proposed for the animal to which it belonged the distinct generic appellation, REGNOSAURUS, with the specific name *Northamptoni.*

IV. LACERTIAN REPTILES.—The recent Lacertians, or true Lizards, are smaller and less highly organized reptiles than the Saurians of the Crocodilian order; and their dermal covering consists of a finer and more delicate squamous integument. They are also characterized by important modification in their osteological structure. The spinal column is almost always composed of concavo-convex vertebræ, with the convexity behind; the ribs are slender and rounded, having a single convex tubercle of attachment. The fossil species are, for the most part, of gigantic dimensions, and deviate in a striking manner from any that now exist. Vertebræ of the recent lacertian type are very rare in the secondary strata; I believe a few in my cabinet, obtained from the sandstone of Tilgate Forest, and which belonged to a very small unknown reptile, are the most ancient examples at present known.

MOSASAURUS. *Bd.* pl. xx.; *Wond.* p. 311; *Petrif.* p. 193. —Of the fossil lizard of Maestricht, named *Mosasaurus* (lizard of the Meuse) from the river adjacent to the quarries of St. Peter's Mountain, in which its remains have been

* The collector will perceive the importance that attaches to the discovery of even a fragment of the jaw of an unknown reptile, containing teeth in their natural position.

discovered, I have given a detailed account at pages 193—196 of *Petrif.* A specimen, with the jaws, and bones of the palate armed with teeth, now in the museum at Paris, has long been celebrated, and is still the most precious relic of this extinct reptile hitherto discovered; a reduced representation is given in *Lign.* 227; and *Pict. Atlas*, pl. lxx. This is the *Mosasaurus Hoffmanni.** The specimen is four



LIGN. 227. MOSASAURUS HOFFMANNI.

(*The original is* $4\frac{1}{2}$ *feet by* $2\frac{1}{2}$ *feet.*)

Remains of the jaws of the great fossil reptile of Maestricht.

and a half feet long, and two and a half feet wide; it consists of both sides of the lower jaw, with the right ramus of the upper jaw in its natural position, and the left, which is displaced, lying across the articular extremity of the left branch of the lower jaw: of the *pterygoid* bones, which are armed with teeth; of the left *tympanic* bone (*os qua-*

* Several fine portions of the jaws, and many vertebræ of this animal, are in the British Museum: see *Foss. Brit. Mus.* p. 139. In a splendid work, *Histoire Naturelle de la Montagne de St. Pierre*, by the late Faujas St. Fond (1 vol. folio, with numerous plates), there are admirable figures of the remains of the Mosasaurus.

dratum), which is but little removed from its natural situation, and connects the lower jaw with the cranium; one of the metacarpal or metatarsal bones, and some fragments.*

The teeth are large, and supported on expanded conical osseous eminences, which are anchylosed to the alveolar ridge of the jaw (*acrodont*). The crown of the tooth is conical and recurved, with the outer face nearly flat, and this space is bordered on each side by a longitudinal ridge; giving the tooth somewhat of a pyramidal figure. (See *Ligns.* 228 —230.) Professor Owen states that the crown consists of a body of simple and firm dentine, with fine and close-set calcigerous tubes, enclosing a simple pulp-cavity; irregular processes of the latter extend as medullary canals into the conical base of the tooth, but not, as in the Iguanodon, into the substance of the coronal dentine; the dentine is invested with a moderately thick coat of enamel.‡

LIGN. 228. MOSASAUROID TEETH.†
½ nat. size.
Cretaceous. North America.
Figs. 1a, 2a. Transverse sections of the crowns of the teeth, figs. 1 and 2 respectively.

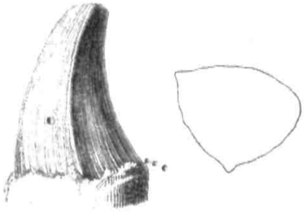
* In the British Museum there is a cast of this specimen, in a case near the bones of the Iguanodon.

† Reduced from figures accompanying Dr. Gibbes's Memoir "On the Mosasaurus and three allied new genera," (with plates,) in the *Smithsonian Contributions*, vol. ii. 1849. This interesting paper comprises much information regarding the Mosasaurians of the Cretaceous deposits of N. America; but we cannot fully coincide with the author in his palæontological determinations.

‡ See Odontography, p. 258, and pl. lxxii.; the student should also consult Cyclop. Anat. Phys. *Art.* TEETH.

The vertebræ of the Mosasaur, as is usual in the existing lizards and crocodiles, are concave in front and convex behind, and the neural arch is united to the centrum by suture. The entire vertebral column of *M. Hoffmanni* appears to have consisted of 131 vertebræ, of which 97 belonged to the tail.* This Mosasaur was about twenty-five feet long.

This extinct lacertian reptile forms an intermediate link between the Saurians without pterygoid teeth (Monitors)



LIGN. 229. TOOTH OF MOSASAURUS: *magn. twice.*
Either a pterygoid tooth of M. Hoffmanni, or a jaw-tooth of M. gracilis.
Chalk. Gravesend.
(In Mr. Wetherell's Collection.)

and those with them (Iguanas). Its crocodilian affinities are but partial.

The Mosasaurus appears to have had webbed feet, adapted for crawling on land as well as for swimming,† and a long and vertically expanded tail, serving as a powerful oar, and enabling the animal to stem the roughest waters.

Prof. Goldfuss has described the remains of another and smaller species of Mosasaurus (*M. Maximiliani*), from

* See Cuvier, *Oss. Foss.* vol. v. pp. 326—334.

† See Prof. Owen's observations on the bones that have been regarded as referable to the extremities of this creature, and especially on the phalangeal and other bones of the Mosasaur of the New Jersey greensand; *Monog. Cret. Rept.* 1851, pp. 36—40.

Upper Missouri, U. S.; and Prof. Owen, in Dixon's "Fossils of Sussex," has established a third and still smaller species (*M. gracilis*),* to which he refers the four or five mosasaurian vertebræ found in the Chalk of Sussex. Two of these (caudal) are figured in *Geol. S. E.* p. 146, and *Petrif. Lign.* 44; and these and others are lithographed in plate viii. of Prof. Owen's *Monog. Cret. Reptilia*, 1851.

The remains of Mosasaurus occur also in the cretaceous sands of New Jersey, U. S. (See Dr. Morton's *Synopsis of the Organic Remains of the United States*, 1834; and the Quart. Journ. of the Geological Society, vol. v. 1849.)

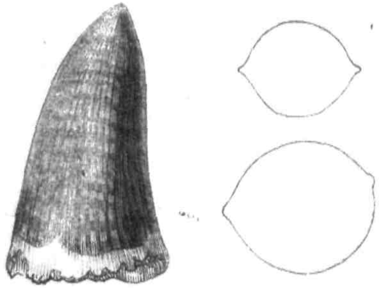
Leiodon anceps.†—Under this name Professor Owen has described a splendid fossil, consisting of a portion of the lower jaw of an acrodont reptile, with teeth, obtained by Edward Charlesworth, Esq. from the Chalk north of the Thames. This specimen was submitted to my inspection, many years since, by Mr. Charlesworth, and I then pointed out the analogy of this acrodont jaw to that of the Mosasaurus.

Prof. Owen in 1840 (*Odontog.* p. 261), and in 1841 (*Rep. Brit. Assoc.* p. 144), described and figured some teeth from the same specimen, which were lent by Mr. Charlesworth. These teeth the Hunterian Professor regarded as characteristic of a new genus of Mosasauroid reptile, to which he gave the name *Leiodon* (in allusion to the smoothness of the teeth). In 1845 (*Rep. Brit. Assoc.* p. 60) Mr. Charlesworth noticed, and in 1846 (*London Geol. Journal*, p. 23, plates iv. and vi.) figured and described, the above-mentioned portion of jaw with teeth, under the name *Mosasaurus stenodon*; and in 1851 Prof. Owen figured and described this specimen under the name of *Leiodon anceps*, which was originally proposed for the animal, as known from its teeth, in 1840.

* See also *Monograph on the Reptiles of the Chalk*, 1851, p. 31, and plate ix.

† Ibid. p. 42, pl. ix. A.

The portion of bone on which the teeth, five in number, are implanted is seven inches in length, and is, in Professor Owen's opinion, the dentary piece of the lower jaw, and not a portion of a pterygoid bone. Mr. Charlesworth has had a section made of four of the teeth, and finds that the pulp-cavities are more or less occupied with solid cones of silex, which must have permeated the osseous parietes of the teeth.



LIGN. 230. MOSASAUROID TOOTH.
Resembling the back-teeth in the lower jaw of Mosasaurus Hoffmanni.
Chalk. Gravesend.
(In the Collection of Mr. Wetherell.)

The teeth of Leiodon have a simple pulp-cavity, surrounded by fine dentine, with an external layer of smooth enamel. The apex of the crown is sharp-pointed; the body of the crown is slightly recurved; its base is expanded into a thick circular fang, which is anchylosed to a short conical process of the alveolar border of the jaw: the teeth differ from those of the Mosasaurus in having the outer side as convex as the inner side, the transverse section being an ellipse with pointed ends, which latter correspond with the lateral trenchant edges of the crown of the tooth: the teeth are more closely set than in the Mosasaur and Geosaur. (*Owen.*)

from the well-known chalk-pit at Burham, Kent. Professor Owen has lately described these interesting remains in detail (*Monog. Cret. Rept.* 1851, pp. 22, &c.), and finds no intrinsic contradiction to exist to the historical evidence adduced as to the probability of the two moieties having belonged to the same individual. In the two specimens there exist sixty-three concavo-convex (*procœlian*) vertebræ, of which fifty-seven form the series between the skull and the pelvis, giving the trunk a length of about eighteen inches. This unique reptile was elongate and snake-like in its form, with the abdomen deep and narrow, like that of the water-snakes: its limbs were short; its tail, from the character of the few caudal vertebræ remaining, must have been relatively long and powerful. This long and slender lacertian was therefore probably to a considerable degree aquatic in its habits, swimming with an undulatory eel-like movement.

The Dolichosaurus (*long-lizard*) presents somewhat of the ophidian character in the number and size of its cervical vertebræ, in the size and shape of its ribs, and in the slender proportions of its trunk and head; but, with these partial exceptions, its affinities are truly lacertian. (*Owen.*)

RHYNCHOSAURUS ARTICEPS. *Lign.* 231.—In a quarry of Upper New Red Sandstone at Grinsell, near Shrewsbury, Dr. O. Ward discovered a skull ($3\frac{1}{2}$ inches long), vertebræ, ribs, bones of the pectoral and pelvic arches, portions of two femora with medullary cavities, and fragments of other bones of a very remarkable lacertian reptile (*Lign.* 231). The lower jaw is preserved with the skull in its natural position. The cranium in its general aspect resembles that of a turtle, rather than of a lizard; for the intermaxillary bones are double, as in Chelonians, and symmetrical, and are not united by a median process; they are very long, and curve downwards, giving the fore part of the skull the profile of a parrot. See *Lign.* 231.

There are no teeth apparent in either jaw; the margin of the upper maxillary has feeble dentations, but in the lower

LIGN. 231. RHYNCHOSAURUS ARTICEPS. *New Red Sandstone; near Shrewsbury*

Fig. 1.—Lateral view of the cranium and lower jaw: ½ *nat size.*

CRANIUM.
a, a. Intermaxillary bones.
b. Nasal.
c. Frontal.
d. Maxillary.
e. Anterior frontal.
f. Lachrymal.
g. Malar.
h. Posterior frontal.
i. Orbital division of posterior frontal.
k. Temporal.
l. Tympanic.

LOWER JAW.
m. Dentary.
n. Coronoid.
o. Articular.
p. Angular.
q. Opercular or splenial.
r. The orbit.

Fig. 2.—The upper aspect of a dorsal vertebra: *nat. size.*

jaw even these indications are wanting, and it is probable that this reptile had its jaws encased by a bony or horny sheath, as in birds and turtles.* (*Owen.*)

THECODONTOSAURUS AND PALÆOSAURUS. *Ly.* p. 306, figs. 348, 349.—Numerous bones and teeth of reptiles occur in the Magnesian Conglomerate, near Bristol, and have been described by Dr. Riley and Mr. Stutchbury in an interesting memoir to which reference should be made for details (*Geol. Trans.* 2d ser. vol. v. p. 349, pl. xxix. xxx.). The bones denote an approach to the lizards; the teeth are implanted in sockets; these reptiles, therefore, belonged to the group termed *thecodont*, and the name *Thecodontosaurus*, given to

* Rep. Brit. Assoc. 1841, p. 150. See also Camb. Phil. Trans. vol. vii. p. 357, tab. 5, 6.

these extinct Saurians by Dr. Riley, has reference to this character. The teeth are pointed, compressed laterally, slightly convex on each side, with a trenchant, finely serrated edge in front and behind ; the fang is subcylindrical. Other teeth from the same deposit, possessing the same general characters, but distinguished by peculiarities of form, have been referred to another genus, named *Palæosaurus*. The vertebræ found associated with the teeth and jaws are biconcave, and are remarkably characterized by the great depth of the spinal canal in the middle of the centrum or body of the vertebræ, so that the spinal chord must have presented a moniliform or bead-like appearance. These reptiles, in their *thecodont* type of dentition, biconcave vertebræ, double-headed ribs, and proportionate size of the bones of the extremities, are nearly allied to the *Teleosaurus*, (see *ante*, p. 679); but they combine a lacertian form of tooth, and a lacertian structure of the pectoral, and probably of the pelvic arches, with these crocodilian characters ; they have also distinctive modifications : such, for example, as the moniliform spinal chord.*

DICYNODON. *Ligns.* 232, 233, 234.—This singular fossil reptile was discovered, by Mr. Bain, in South Africa. It is distinguished, by some remarkable peculiarities of structure, from other animals of the Saurian order ; of which it represents a new tribe, or sub-order. The cranium is narrow ; the nostrils are divided, as in Lizards, and not confluent, as in Chelonia ; the skull, in other respects, much resembles in general appearance that of a Turtle ; the orbits are large ; the jaws are edentulous, as in the Turtles, with the exception of a pair of long tusks,† implanted in sockets in the upper maxillary bone, like those of the Walrus ; these tusks are of a finer texture than that of the Crocodile's teeth, and

* Owen ; Rep. Brit. Assoc. 1841, p. 155, &c.

† Hence the generic name, *Dicynodon* : from δὶς (twice), and κυνόδους (canine tooth).

almost as dense as in the Hyæna. These creatures present in the most striking manner that blending of the peculiarities of several existing orders, which is continually presented to the palæontologist; for with a type essentially lacertian are combined crocodilian and chelonian modifications. Although no vestiges of these reptiles have been discovered in England or in Europe, yet the occurrence of an allied form, the *Rhynchosaurus* (*Lign.* 231), in our New Red Sandstone, and the probability that the South African reptiliferous deposits may, from their position, belong to the Triassic Epoch, induce me to give a somewhat extended notice of these extraordinary fossils: and I am led to do so on another account, namely, because the memoir,* of which the following is a brief abstract, is so excellent an example of the manner in which such investigations should be conducted, so as to arrive at any satisfactory conclusions as to the characters and relations of the lost types of beings, whose fragmentary and petrified relics are the only vestiges that remain.

The fossils under consideration were exhumed some years since by Mr. Andrew Geddes Bain, from the intensely hard argillo-calcareous nodules of the sandstone strata which range over an immense tract of country beyond the mountains north of Capetown.† The extensive series of these and other fossils from South Africa, collected by the indefatigable labour of Mr. Bain, have lately been deposited in the British Museum; but the specimens described and figured in Prof. Owen's Memoir, above alluded to, are nearly all that have as yet been successfully worked out from the

* Prof. Owen's Memoir on the Dicynodon, Geol. Trans. 2d ser. vol. vii. pp. 59, *et seq.*; and plates iii. to vi.

† For a notice of the geological structure of this region, see Mr. Bain's paper in Geol. Trans. 2d ser. vol. vii. pp. 53, &c.; and the abstract of a later Memoir by Mr. Bain, in the Literary Gazette, Dec. 18, 1852 (No. 1874).

LIGN. 232.

LIGN. 233.

LIGN. 232 and LIGN. 233. DICYNODON LACERTICEPS. (*Owen.*)
South Africa.
(See Geol. Trans. 2d ser. vol. vii. pl. iii.)

The letters of reference correspond in the two figures.

LIGN. 232. Side view of the Cranium and Lower Jaw: ⅓ *nat. size.*
LIGN. 233. Upper aspect of the Cranium: ⅓ *nat. size.*

Cranium and Upper Jaw.

a, a. Intermaxillary bone.	*g, g.* Malar.	*n, n.* Nasal apertures.
b, b. Nasal.	*h, h.* Post-frontal.	*o, o.* Orbits.
c, c. Frontal.	*i, i.* Parietal.	*oc, oc.* Basi-occipital.
d, d. Maxillary.	*k, k.* Temporal.	*t, t.* Temporal fossæ.
e, e. Prefrontal.	*l, l.* Tympanic.	*t', t'.* Canine teeth in the upper jaw.
f, f. Lachrymal.	*m, m.* Mastoid.	

Lower Jaw.

1. Dentary bone.	3. Opercular.	5. Articular.
2. Coronoid.	4. Angular.	6. Surangular.

exceedingly hard matrix in which the bones are imbedded. These consist of crania and jaws, referable to four species.*

The most striking character in these crania is the presence of a pair of long, sharp-pointed, gently curved tusks, implanted in the superior maxillary bones, and which descend, one on each side of the fore-part of the lower jaw, as seen in *Ligns.* 232 and 233, *t′*, *t′*. This is a dental character which, with this exception, is peculiar to the mammalia (the Walrus, Musk-deer, and Machairodus), and is rare even in that class.

Examination of the skull.—One of the crania showed the median undivided process of a single *intermaxillary* bone, ascending and separating *two distinct anterior nasal apertures;* in another, the boundaries of a very much contracted cranial cavity were evident: these characters combined to prove that the skulls were referable to air-breathing oviparous and cold-blooded animals, or Reptiles; but neither to Crocodilians nor Chelonians, and for the following reasons:—

1stly. The originals were not mammalians; for no mammalian has the *intermaxillary bone single* (as in *Lign.* 233, *a*), or the *external bony nasal aperture double;* and neither mammalian nor bird has the cavity for the brain so relatively small as in this fossil.

2dly. They were not Crocodiles; for in all crocodiles the intermaxillary bone is divided by a suture, and the anterior nasal aperture is single and on the median line, as in mammalia.

3dly. They were not Chelonians; for all turtles have the

* Namely, Dicynodon lacerticeps (*lizard-head*), D. testudiceps (*turtle-head*), and D. strigiceps (*owl-head*), the trivial names of which have reference to the general form of the head; and D. Bainii, the largest, but unfortunately as yet the least known species, which takes the name of the intelligent and energetic discoverer and collector of the whole.

nasal opening single and placed in the middle of the fore-part of the skull, in the very situation which, in the Dicynodon, is occupied by the convex imperforate median plate of the broad intermaxillary bone.

4thly. They could not be Fishes, as those animals have no well-defined external respiratory nasal apertures.

5thly. They were neither Batrachians (frogs) nor Ophidians (serpents); for, although the reptiles of these two orders have a single intermaxillary and double nostrils, like the fossils, the latter are at once separated from them by the presence of a strong and complete zygomatic arch (*Ligns.* 232 and 233, *g*, *d*), continued from the tympanic bone to the large immovably articulated superior maxillary.

Lastly, the characters last named, and the presence of vertical tympanic pedicles (*Lign.* 232, *l*), suspended by their upper part to the junction of the zygomatic and mastoid bones, prove the affinity to the lacertians or true lizards.

These bidental crania have certain characters in common with that of the Rhynchosaur, which is also, as we have before seen, of the true lacertian group, but the Dicynodonts are more nearly allied to the Crocodiles and the Chelonians than the Rhynchosaurus appears to be.

Referring to the original Memoir for anatomical details, I must limit this notice to a few additional general remarks. Both the jaws are edentulous, with the exception of the pair of tusks, as in Chelonians; there are no traces of teeth, or of their sockets, in the lower jaw, whichis short and very deep, and anchylosed at the symphysis, as in turtles; the alveolar border forms a smooth trenchant edge, which shuts within the corresponding part of the upper jaw: it is probable that both jaws were covered by horn, as in the chelonians. The tusks are implanted in wide and deep conical alveoli in the suborbital part of the maxillary bone, and project about two inches beyond the sockets (*Lign.* 232); they are long and pointed, and are directed downwards and forwards, with a

slight backward curve, and slightly converge towards their extreme points (*Lign.* 233). These teeth consist of a simple body of unvascular dentine, with a very thin external coat of enamel. The tooth-ivory is more dense than in any known reptile, and approaches in its intimate texture that of the canines of the carnivorous mammals. The base of the tooth has a conical cavity (*Lign.* 234), indicating a persistent matrix or dental pulp, the rest of the tooth without the socket being solid. There are no traces whatever of the germs of successional teeth. It is therefore inferred, that, like the tusks and scalpriform incisors of mammalia, the canine or maxillary teeth of the Dicynodon were capable of constant growth and renovation; thus offering an approach to the typical dentition of mammalia, unknown in any other reptiles.

LIGN. 234.
DICYNODON TESTUDICEPS. (*Owen.*)
(Geol. Trans. 2d ser. vol. vii. pl. v. figs. 3 & 4.)
Fig. 1. Longitudinal section of the fang of the tooth implanted in its socket: ½ *nat. size.*
1a. Transverse section of the tooth.

As the points of the teeth in the only known perfect specimen are unworn, it is inferred that these tusks were not employed either as instruments for obtaining food, as in the Dugong, or for locomotion, as in the Walrus, but were simply offensive and defensive weapons.*

A few sub-biconcave vertebræ and other undetermined bones were associated with these remains; and many similar crania, both with and without the tusks, and other cranial remains with jaws armed with numerous teeth, as well as

* See Prof. Owen's detailed account of these curious dental organs in the Memoir already referred to, and in the *Art.* TEETH, in the Cyclopædia of Anatomy and Physiology.

indications of smaller reptiles, form part of Mr. Bain's collections now in the National Museum, awaiting the skilful manipulation of the experienced workman to clear away their hard investing matrix, and the scientific examination of the palæontologist to elucidate their zoological characters.

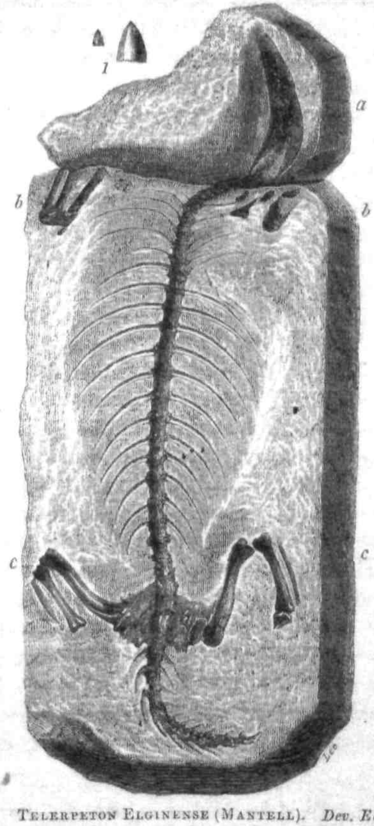
TELERPETON ELGINENSE (MANTELL). *Ligns.* 235 and 236. —This is the oldest Reptile yet known.* Its remains consist of the impression† of a skeleton of a small, four-footed, vertebrate animal, on a block of the Old Red or Devonian Sandstone from Spynie, near Elgin, North Britain. It was obtained by Mr. Patrick Duff, in 1851; and a detailed description of this unique fossil, with an illustrative plate, will be found in the Quarterly Journal of the Geological Society, vol. viii. pp. 100, *et seq.*; together with a notice by Captain Brickenden of the geology of the district where the specimen was found, and a paper on some fossil foot-prints,‡ discovered by this geologist in the same rock.

By reference to *Lign.* 235, it will be seen that the cranium is almost wholly lost; a few conical teeth, mostly of a very small size, were observed in connexion with the vestige of the jaws. The spinal column is represented by the impressions of about thirty-six vertebræ, eleven or twelve of which belong to its caudal portion. The vertebræ present some faint evidence of their possessing a bi-concave form: the length of one of the dorsal vertebræ is $\frac{1}{9}$th of an inch. There are twenty-one pairs of long slender ribs. The pectoral arch and anterior extremities have nearly disappeared

* The word TELERPETON simply denotes the remote antiquity of this Devonian reptile of Scotland, τῆλε (far off), ἑρπετὸν (reptile); the trivial name, *Elginense*, records the locality from whence it was obtained.

† A model of this most delicate and valuable impression has been deposited in the palæontological gallery of the British Museum.

‡ A general notice of the fossil foot-prints, or *Ichnolites*, that have been referred to Reptiles will be given at a subsequent page of this chapter.



LIGN. 235. TELERPETON ELGINENSE (MANTELL). *Dev. Elgin.*

Impression of the skeleton (*nat. size*); showing the outline of the vertebral column, ribs, pelvis, femora, tibiæ and fibulæ, part of the caudal series of vertebræ, the left humerus, radius, and ulna, imperfect traces of the right anterior extremity, and obscure indications of part of the cranium.

a. The remains of the cranium.

b, b. Imprints of portions of the anterior extremities.

c, c. Well-defined impressions of the thigh-bones and leg-bones, with an obscure sub-quadrangular pelvis.

1. One of the teeth: *nat. size* and *mag.*

in the fracture of the stone. The pelvis and sacrum are very obscure; the latter is formed probably of two anchylosed vertebræ. The thigh-bones are somewhat curved; the tibia is gently bowed, and expanded at each extremity. There are no remains of the feet.

The structure of this reptilian skeleton, as far as the specimen can serve to show, indicates a peculiar type of organization, in which, as in numerous other extinct forms, in this, as in other Classes, osteological characters are associated which in existing oviparous quadrupeds are restricted to distinct orders and genera.

LIGN. 236.
TELERPETON ELGINENSE (MANTELL).
Outline of the restored form of the original reptile: ¼ *nat.*

The *lacertian* affinities of the Telerpeton are well marked in the relative size and form of the bones of its extremities, the situation of its pelvis, and probably in the articulation and the length of its ribs; but the contracted, biconcave centrum, and the short neural spine of the vertebræ, as well as the horizontality of the articulating surfaces of the zygapophyses, and the general uniformity of character throughout the spinal column, are to be regarded as *batrachian* modifications. Probably the original was a peculiar type. which, in the present state of our knowledge, it would

be rash to ascribe to either order. The length of the original animal could not have exceeded six or seven inches. *Lign.* 236 represents in outline the probable form of this small, but most interesting reptile.

V. PTEROSAURIANS, OR FLYING REPTILES.—PTERODACTYLUS (*wing-fingered reptile*). *Lign.* 237. *Petrif.* p. 187; *Wond.* p. 577; *Bd.* pl. xxi. xxii.—The extinct reptiles denominated *Pterodactyles*, constituting a few genera of an order of Saurians organized for aërial life,* are unquestionably the most marvellous even of the wonderful beings which the relics of the Age of Reptiles have enabled the palæontologist to reconstruct. With a long-snouted head and long neck, much resembling that of a bird, bat-like wings, and a small trunk and tail, with lacertian affinities in its skull, teeth, and skeleton, and with a bird-like structure of sternum and scapular arch, these creatures present an anomaly of structure as unlike their fossil contemporaries, as is the duck-billed Ornithorhynchus, of Australia, to existing animals. The cranium, or brain-case, is small; the jaws are either long, and armed with numerous sharp-pointed teeth, or toothless, like those of a bird. The teeth of the Pterodactyle are all laniary; they are simple, of a conical form, recurved, with but little difference in their form and size, and implanted in distinct sockets, with wide intervals between each. In some species there are twenty-eight or thirty in the lower, and twenty-two in the upper jaw.

The orbit is very large; the sclerotica consists of an annular row of bony plates, but less in number than in the

* The only known recent reptile at all analogous is the little *Draco volans* of the East Indian Islands; but even this can scarcely be regarded as a flying animal, its lateral membranous expansions, which are rather parachutes than wings, and formed by elongated ribs, not by the fingers, presenting but a rudimentary condition of wings compared with those of the Bat and the Pterodactyle.

Ichthyosaurus; the external orifice of the nostrils is near the orbits; remains of the *os hyoides* (bone of the tongue) have been observed.

The cervical vertebræ are large and strong, and capable of great flexibility forwards and backwards, probably to allow the head to fall back to the centre of gravity during flight. There are frequently traces of ossified condition of

LIGN. 237. PTERODACTYLUS CRASSIROSTRIS: ⅓ *nat. size.*
Oolite. Solenhofen.

the tendons of the muscles of the neck. This is well seen in *P. macronyx* and *P. crassirostris* (*Lign.* 237), and is a peculiarity dependent on the additional support required by the long neck of the animal.

The dorsal vertebræ are from seventeen to twenty in number. The sacrum is formed by the coalescence of two

vertebræ only, as in existing reptiles, and not of many, as in birds and certain extinct saurians. The tail is generally short, an unusual character with saurians; but a species with a long tail occurs at Solenhofen.

There are five toes or digits on each foot; the outer finger of the fore-arm is immensely elongated, for the support of a membranous expansion (the impression of this wing-membrane is preserved on the stone in some examples); and the other digits, of fore and hind feet, terminated in long curved claws. The size and form of the extremities show that the *Pterodactylus* was capable of perching on trees, of hanging against perpendicular surfaces, and of standing firmly on the ground, when, with its wings folded, it might crawl on all-fours, and walk or hop like a bird. A reference to the graphic description of the characters and probable habits of these beings, by Dr. Buckland, *Bd.* i. p. 221, and the beautiful illustrations accompanying it (*Bd.* ii. pl. xxi. xxii.), will equally instruct and gratify the reader.

The most perfect examples of the *Pterodactyles* have been discovered in the lithographic stone of Monheim, Pappenheim, and Solenhofen, where their bones are associated with the remains of *Dragon-flies* (see p. 551) and other insects. In England, bones of these reptiles have been obtained from the Lias of Lyme Regis, from the Oolitic slate of Stonesfield, from the Wealden strata of Tilgate Forest, and the Chalk of Kent.* One of the most interesting British specimens

* For a detailed description of the Pterosaurian remains from the English Chalk, with numerous beautiful illustrations, see Prof. Owen's *Monograph*, published by the Palæontographical Society, 1851. Other important memoirs on Pterodactyles and their structure, not mentioned in the text, are, by Von Meyer, in *Nova Acta Acad. Nat. Curios.* vol. xv. part ii. and *Palæontographica*, part i. 1846; Goldfuss, *Nova Acta*, vol. xv. part i., and *Reptilien der Vorwelt*, 1831; Prof. Owen, *Quart. Journ. Geol. Soc.* vol. iii. and Mr. Bowerbank, *ibid.* vol. iv.

consists of a considerable part of the skeleton of a species about the size of a Raven, discovered by the late Mary Anning, in the Lias of Lyme Regis, and now deposited in the British Museum.* It consists of the principal bones of the extremities, and of several vertebræ, and is figured and described by Dr. Buckland, *Geol. Trans.* 2d ser. vol. iii. pl. xxvii. This specimen is distinguished by a greater length of the claws (whence the name of the species, *P. macronyx, long-claw,*) than in any previously known.

The remains of the Pterodactyles of the Chalk, for the most part, indicate a large size for the original animals. It has been estimated that some of these gigantic flying reptiles possessed an extent of wing surpassing that of the great albatross. The *Pterodactylus Cuvieri* had probably an expanse of wing not less than eighteen feet from tip to tip; another Chalk species, *P. compressirostris*, fifteen feet; whilst the *P. macronyx*, of the Lias, measured about four feet seven inches from the extremity of one wing to that of the other.†

VI. CHELONIAN REPTILES.—Those singular reptiles, commonly known by the name of Tortoises and Turtles, and designated by naturalists CHELONIA (from *Chelone*, the Greek term for a Tortoise), are distinguished from all other animals by the osseous cuirass in which their bodies are enclosed, the head and neck, extremities, and tail, alone being excluded. This remarkable bony case is produced by the extraordinary development of the bones of the thorax and back; and consists of an under (*sternal*) and an upper (*dorsal*) portion. The breast-plate, or *plastron*, which is the true sternum, is composed of nine pieces of bone, eight of which are in pairs, and the ninth, or odd plate, is situated between the four anterior plates. The variation in the form of these plates is considerable, and affords important

* See *Petrif.* p. 189.

† Bowerbank, *Rep. Brit. Assoc.* 1851, and Owen, *Monograph*, p. 104.

distinctive characters. In the young state of land and fresh-water tortoises, there are vacancies between the pieces, which are filled up in the adult, the whole being ultimately united into one bony plate ; but in the marine turtles (and also in the *Trionyces*, or soft tortoises), these pieces do not completely unite, and interspaces always remain. The bones of which the dorsal buckler, *carapace*, or upper shield is composed consist of eight of the ten pairs of ribs, united by a longitudinal series of angular plates, which are attached to the annular part of the vertebræ throughout the whole, or a great part of their length, according to the age and species of the individual.* Numerous modifications exist in the form of the buckler, in its flatness or convexity, in the degree of extension of the ribs, and their angular plates, and in the characters of the scutes or horny integument with which the carapace is covered ; and with corresponding variations in the head, and in the locomotive extremities, in the numerous species and genera of the Chelonian reptiles, according to their adaptation to a terrestrial, fluviatile, or marine existence.

The animals of this order are arranged in four principal groups, viz. the marine, or Turtles (*Chelones*) ; the fluviatile, or river-Tortoises (*Trionyces*) ; the marsh-Tortoises (*Emydes*) ; and the terrestrial or land-Tortoises (*Testudines*). The marine Chelonians generally feed upon vegetables ; the *Emys* and *Trionyx* approach more nearly to the terrestrial than to the marine species ; they are carnivorous, feeding on frogs, fishes, fresh-water mollusca, and other small animals. The *Trionyces* differ from their congeners in being destitute of a horny external integument, having no scutes on the

* In the Monograph on Eocene Reptiles, 1849, Prof. Owen has given a succinct account of the carapace and plastron of the *Chelone*, and a brief notice of the composition and homologies of these bony encasements in the Tortoise, with references to more particular and comprehensive memoirs by himself and others.

buckler or any other part of the body; but the osseous carapace is invested with a strong tough skin, which equally covers the dorsum and sternum, to which it firmly adheres; the dermal surface of the bones in these Tortoises is always rugose, and either granulated, or covered with punctations and depressions. The buckler of the Trionyces is of a depressed form, with a soft flattened margin. The Testudinidæ, or land-Tortoises, are too well known to render any description requisite for our present purpose.

In the marine species, eight pairs of ribs and thirteen plates of the longitudinal series form the buckler; the ribs or costal plates are united to each other through a great part of their extent; but towards their distal or outer extremities each rib contracts, and terminates in a point, which is supported on a marginal series of bony plates; the intervals between the ribs are filled up in the living animal by a cartilaginous membrane which never becomes ossified. This character, therefore, affords an important aid in the discrimination of the fossil remains of this family.*

In the terrestrial and the marsh Tortoises, the ossification is complete in the adult state; but in the fluviatile Trionyces, which are without a horny integument, there is no border, or marginal series of bony plates, and the extremities of the ribs are therefore always distinct, and generally have an obtuse extremity. The skeletons of the three groups present corresponding modifications, and an accurate knowledge of the osteology of the recent animals is necessary to enable the palæontologist to arrive at secure conclusions as to the characters and relations of the fossil species.† We can only advert to one remarkable osteo-

* The reader will recognise this peculiarity in the gilded skeleton of the carapace of Turtles, frequently exhibited in the soup-shops of the metropolis.

† The student should consult *Cuvier's Ossemens Fossiles*, tom. v. part iime. chap. ii.: and Prof. Owen's *Monographs*, published by the Palæontographical Society, 1849, 1851, 1853. The Penny Cyclo-

logical character,—the construction of the shoulder, which differs from that of all other animals, in being situated within the cavity of the thorax, instead of without. In consequence of this modification, a process of the shoulder-blade (*scapula* or *omoplate*), termed the *acromion*, is largely developed, and the shoulder-bone is tri-mucronate, or three-pronged, consisting of a short, thick head, containing a concavity (which, with that on the coracoid-bone, forms a socket for the arm-bone), and of two diverging branches. This form is so peculiar, that the collector can be at no loss to recognise the shoulder-bone of a *Chelonian*, should it come under his notice with other fossil relics (see *Foss. Til. For.* pl. xix. *fig.* 11). The shoulder-blade and its associated coracoid-bone undergo certain modifications in the three groups of Turtles, by which the anatomist may pretty certainly determine the terrestrial, fluviatile, or marine character of the animals to which they belonged. The successful application of a perfect knowledge of this department of osteology, is admirably exemplified in the works to which reference has been made; and even but a slight acquaintance with its principles will often enable us to obtain some general information as to the nature and relations of fossil Chelonians.

The student will remember that all the Chelonians are edentulous, *i. e.* toothless*; their bony jaws being covered by horny sheaths, as in birds; these mandibles are therefore the only dental organs that can occur in a fossil state.

Fossil Turtles and Tortoises.*—Some of the earliest indications of the presence of Reptiles on our planet are afforded by the foot-prints of Chelonian animals on the

pædia, *Art.* Tortoises, contains an excellent summary of the osteology of these reptiles, also an abstract of Professor Owen's Report on the Fossil *Chelonia*.

* See *Rep. Brit. Assoc.* 1841, pp. 168, *et seq.*

surfaces of the layers of sandstone of the Old Red formation at Elgin, and of the New Red in Dumfriesshire, at Storeton, near Liverpool, and at some places in Germany (see *Bd.* i. p. 259, and p. 265, note). But no osseous remains of the animals of this family have hitherto been found in strata antecedent to the Oolite. The Solenhofen quarries (Kelheim) have yielded the bones and carapaces of several Emydian tortoises, and some remains of Chelonians have been found at Stonesfield, and in the Portland Sandstone.* In the Jura limestone at Soleure, two large species of Emydians have been discovered. The Wealden and Purbeck formations abound in Chelonian remains of both fluviatile and marine genera. From the Isle of Purbeck numerous fine examples have been obtained;† my own researches in the strata of Tilgate Forest (*Foss. Til. For.* p. 60) have also brought to light several species, and in particular an interesting Chelonian related to the soft-skinned, fresh-water tortoises, *Trionyces* (*Geol. S. E.* p. 255). In the Cretaceous formation of England the remains of these reptiles are not frequent. The Greensand of Cambridgeshire (*Rep. Brit. Assoc.* 1841, p. 172,) has yielded a marine species, and that of Kent a fine Emydian form (Owen, *Monog.* 1851); and in the White Chalk a few examples have been obtained, to which we shall hereafter more particularly allude. On the Continent fine examples have been found in the slate of Glaris (see *Bd.* pl. xxv′.); and in the upper Cretaceous strata of the Netherlands, at Maestricht, and at Melsbroeck, near Brussels, many beautiful specimens of fresh-water tortoises (*Emydes*), and marine turtles (*Chelones*), have from time to time been

* See *Rep. Brit. Assoc.* 1841, pp. 160 and 169.

† Some of the most beautiful of these almost perfect specimens have lately been figured and described by Prof. Owen in his Monograph on the Fossil Chelonian Reptiles of the Wealden and the Purbeck; Palæontographical Society, 1853.

obtained; these are figured and described by Baron Cuvier (*Oss. Foss.* tom. v. pp. 236, 239). In the Eocene strata of England, several species of Chelonians have been collected; of these eleven belong to the marine genus *Chelone;* eight to the fresh-water *Trionyx;* and eight to the marsh-tortoises, *Emys* and *Platemys*. The Isle of Sheppey and Hordwell have yielded the majority of these relics; the turtles are smaller than the recent analogues, which now inhabit intertropical latitudes.* The Eocene strata of France contain several fresh-water tortoises, some of which are referable to the Emydes, and others to the Trionyces. From the gypsum beds, near Paris, the remains of one or two species of Trionyx have been obtained (*Oss. Foss.* tom. v. p. 222), of another at Aix, in Provence, and of three or four species in other localities. A fine specimen of fresh-water tortoise from Œningen, near Constance, is described and figured by Professor Bell in Geol. Trans. 2d ser. vol. iii. The fossil remains of *Testudinidæ*, or land-tortoises, are exceedingly rare. No well-determined remains are known in the British strata; the impressions of scutes found in the Stonesfield slate, and the footprints above described, being the only indications of the existence of these reptiles. The presence of land-tortoises in the strata of France appears to be equally problematical, for the relics obtained from Montmartre and Aix (*Oss. Foss.* p. 245) afford no certain data as to the character of the original.

The Tertiary formations of India, however, have furnished decided examples of fossil terrestrial tortoises; and among the innumerable relics of the beings of an earlier world, which the indefatigable labours of Dr. Falconer and Captain Cautley have brought to light, and which those accomplished naturalists have so skilfully developed, are the

* Rep. Brit. Assoc. 1841, p. 177, and Monograph on Fossil Reptiles, Pal. Soc. 1849, in which the anatomical details are given with the characteristic accuracy and minuteness of the author.

remains of land tortoises of prodigious magnitude (*Colosso-chelys atlas*); one specimen indicating a length of twelve or fourteen feet, with a breadth and height of corresponding proportions! These remains are associated with the bones of gigantic extinct mammalia, allied to the *Palæotheria* and other pachyderms of the eocene deposits of the Paris basin; and with those of Emydian and Crocodilian reptiles.*

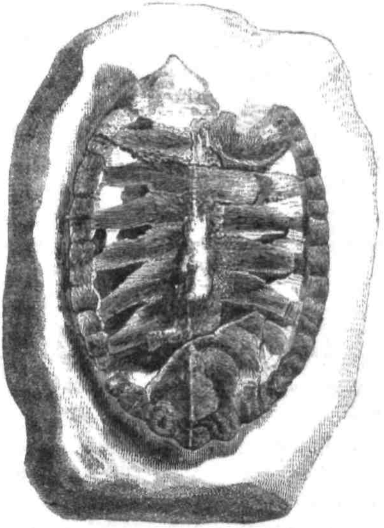
FOSSIL MARINE TURTLES.—In illustration of this subject, I select a specimen discovered in the lower Chalk, at Burham, Kent, which is remarkable for its beautiful state of preservation, and its peculiar osteological characters.

CHELONE BENSTEDI. *Lign.* 238.—To Mr. Bensted, of Maidstone, whose discoveries have rendered his quarry of Kentish Rag classic ground to the British palæontologist, I am indebted for this splendid fossil turtle. The quarry whence it was obtained is situated at Burham, a short distance from the banks of the Medway, between Chatham and Maidstone, and presents a good section of the lower Chalk. This locality is rich in fossil remains, rivalling in this respect the quarries near Lewes, Worthing, and Arundel, in Sussex. Two other fossil Turtles have been obtained from this quarry, and now enrich the cabinets of Sir P. Egerton and Mr. Bowerbank. Other relics of Chelonians found in this place are four marginal plates of the carapace, and fragments of ribs,† some marginal plates of a much larger individual, mandibles, and other fragments, which are noticed in Prof. Owen's Monograph, 1851. The specimen, of which *Lign.* 238 is a reduced figure, consists of the dorsal buckler or carapace almost entire; it is of a depressed elliptical form, with a longitudinal median ridge; it is six inches in length, and three and a half inches in breadth across the middle. It is composed of eight ribs, or costal plates, on each side the dorsal ridge, which is formed of ten neural plates; and

* *Petrif.* pp. 11 and 468.

† See *Geol. Proceed.* vol. iii. p. 299.

there is a border of marginal plates. These plates are united to each other by finely indented sutures, and bear the



LIGN. 238. CHELONE BENSTEDI: ½ *nat. size.*
Chalk. Kent.

The dorsal shield or carapace of this specimen admits of being removed: and four sternal plates, a coracoid bone, and several vertebræ are then exposed.

imprints of the horny scutes, or tortoise-shell, with which they were originally invested. The expanded ribs are united throughout the proximal half of their length, and gradually taper to their marginal extremities, which are supported by the plates of the osseous border.* This description applies to the specimen as seen in *Lign.* 238; but Mr. Bensted so

* See also *Phil. Trans.* 1841, p. 153, pl. xi. and xii.; and *Palæontograph. Monograph,* 1851, p. 4, plates i. ii. and iii.

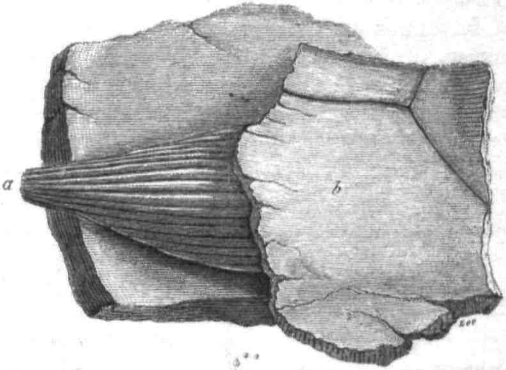
skilfully cleared away the chalk as to admit of the removal of a great part of the dorsal shield, by which means some of the vertebræ, four sternal (*hyosternal* and *hyposternal*) plates, and one of the coracoid bones are displayed. This brief description will suffice to convey a general idea of the characters of this fossil, which differs from any known recent turtle, and possesses some anomalous features, that appear to indicate some slight Emydian affinities.

Among the numerous fossils obtained from the Chalk of Sussex, the only trace of a Chelonian reptile that has come under my observation is the bony mandible or beak of a Turtle, *Lign.* 239. Its surface displays a fibrous cancellated structure, denoting the attachment of the horny sheath with which, in a recent state, it was covered. More or less perfect specimens of such mandibles also occur in the Chalk of Kent and elsewhere, but no bones of the skull have yet been met with in that deposit. In the Green-sand of Cambridgeshire, however, the cranium of a small turtle has been found. It is figured and described by Prof. Owen as *Chelone pulchriceps* (*Monograph*, 1851).

LIGN. 239.
BEAK OR MANDIBLE OF A TURTLE: *nat. size.*
Chalk. Lewes.

CHELONE BELLII. *Lign.* 240, *Petrif.* 155.—In the strata of Tilgate Forest, fragments of the carapace, of the plastron or sternum, and of the marginal plates, with some of the bones of the extremities, of a large marine turtle have been discovered; several specimens are figured in *Foss. Til. For.* pl. vi. and vii. Some examples must have belonged to an individual at least three feet in length. Unfortunately, the

specimens hitherto obtained are very imperfect, and do not exhibit essential distinctive characters, with the exception



LIGN. 240. CHELONE BELLII* (G. A. M.). *Wealden. Tilgate Forest.*

Portion of a costal plate, and the extremities of a rib: *nat. size.*

(*Foss. Tilg. For.* pl. vi. fig. 2.)

a. The striated pointed extremity of rib.
b. The distal portion of the costal plate.

of the ribs, which are united to within a short distance of their distal or marginal extremities; hence the costal inter-

* The remains of this reptile were noticed in the "Fossils of the South Downs, or Illustrations of Geology of Sussex," 4to. 1822, p. 47, and subsequently figured in the "Illustrations of the Geology of Sussex, with figures and descriptions of the Fossils of Tilgate Forest," 4to. 1827, p. 60, pl. vi. and vii.; and this extinct *Chelone* was regarded as a species, characterized by the great development of the rib-plates, and named after Professor Bell, the eminent zoologist, in the first Edition of the "Medals." But in the *Monograph, Weald. Rept.* 1853, this determination has lately been overlooked; and the specimen figured *Tilg. Foss.* pl. vi. fig. 2, is referred to the newly named *Ch. costata*, characterized by its broad and prominent ribs. A third name even (*Ch. Mantelli*) has been bestowed on this interesting fossil, by a German palæontologist.

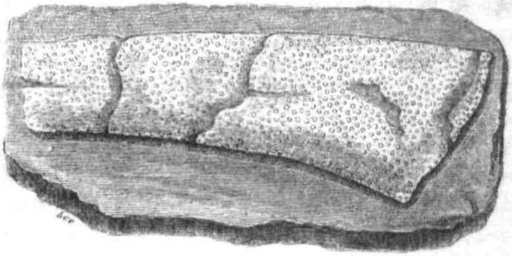
spaces are reduced to much smaller dimensions than in any recent or fossil Turtles with which I have had the means of comparing them. The fragment of a rib, imbedded in Tilgate grit, figured *Lign.* 240, well exhibits this character.

FOSSIL FRESH-WATER TORTOISES.—The remains of fresh-water Tortoises, referable to the *Emydidæ*, occur in the Purbeck and Wealden strata (Owen's *Monograph*, 1853, and *Rep. Brit. Assoc.* 1841); the resemblance of some of these to the Jurassic species from Soleure was noticed by Cuvier (*Oss. Foss.* vol. v.). Among the Chelonian remains of the Wealden, some of the most remarkable are the costal plates and other bones of a Tortoise, which in its essential characters is closely allied to the Trionyces,* but differs from the recent forms, in having possessed a dermal horny integument, formed of scutes of tortoise-shell. The chelonians of the genus Trionyx (so named from their having three claws) have the extremities of the ribs free, and not articulated to a border of marginal plates, and there are intervals between their costal plates even in the adult state. The external surface of the bones of the buckler is covered with granulations, or with little pits, for the attachment of the soft skin, the only integument with which these animals are invested; and, being destitute of horny scutes, their bones exhibit no furrows, as in the other genera. But the fossil rib-plates (see *Lign.* 241) have a shagreen-like or punctated surface, like the recent Trionyces, and at the same time bear the imprints of horny scutes; and, instead of being nearly of an equal width throughout their entire length, as in the existing species, have one extremity much wider than the other, as in the land-tortoises. From the slight degree of convexity of the ribs, it is evident that the carapace was much flattened, as in the Trionyx.† Except in having a

* The relations of these peculiar remains to *Trionyx* were pointed out in *Foss. S. D.* 1822, p. 47.

† See *Petrif.* p. 157, &c.

defensive dermal integument, and agreeing in this respect with many of the Crocodilian reptiles, with which its bones are associated, the original must have closely resembled the

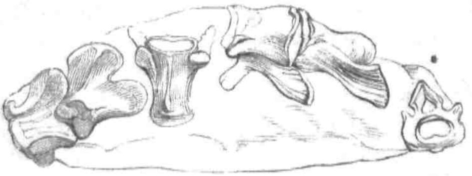


LIGN. 241. TRETOSTERNON BAKEWELLI:* ⅓ *nat. size.*
Wealden. Tilgate Forest.
(*Foss. Tilg. For.* pl. vi. fig. 1.)
One of the costal plates.

existing predaceous fresh-water soft Turtles; and, doubtless, like those reptiles, inhabited the muddy beds of lakes and rivers, preying upon the eggs and young of the larger reptiles, and on the uniones and other fluviatile mollusca, whose shells are very commonly found imbedded with its remains.

* This Tortoise, with the sanction of Baron Cuvier, was described under the name *Trionyx,* in *Foss. Tilg. For.* 1827, p. 60, and its distinctive characters were pointed out. In *Geol. S. E.* 1833, p. 255, the specific name *Bakewelli* was proposed in honour of the late ROBERT BAKEWELL, ESQ., whose excellent works have so greatly promoted the advancement of geology; a privilege to which, as the original discoverer of the species, and of its zoological relations, I was fairly entitled. But this name does not appear in the list of British Chelonians, either in *Rep. Brit. Assoc.* 1841, or in Mr. Morris's *Cat. Brit. Org. Rem.* 1843. With a melancholy pleasure I now restore the name of my lamented friend, as a just, but very inadequate tribute of respect to his memory.

VII. OPHIDIANS, OR SERPENTS. *Lign.* 242.—The remains of the vertebral columns of extinct Serpents were discovered many years since in the London clay of the Isle of Sheppey, and specimens were obtained by the celebrated HUNTER, and preserved in his museum. These specimens, together with others in the collections of Messrs. Saull, Bowerbank, Dixon,



LIGN. 242. PALÆOPHIS TOLIAPICUS: ⅔ *nat. size.*
London Clay. Isle of Sheppey.
Six concavo-convex vertebræ of the trunk.

Combe, and S. Wood, have been figured and described, and their relations to existing types elaborately worked out, by Professor Owen.* The *Palæophis typhæus*, from the Bracklesham clay, had a length of about twenty feet, and, from the compressed character of its caudal vertebræ, was probably a sea-serpent. A somewhat smaller species also occurs at Bracklesham. The Sheppey specimens are referred to another species of this extinct genus, namely, the *P. toliapicus* (*Lign.* 242); it was from ten to twelve feet in length. The remains of two species of land-serpents, respectively about four and three feet long, have been found at Hordwell Cliff. These belong to the extinct genus *Paleryx*, thus named in reference to the near affinities of

* Geol. Trans. 2d ser. vol. vi. p. 209, &c. pl. xxii.; Rep. Brit. Assoc. 1841, p. 180; "Dixon's Geology and Fossils of Sussex," pp. 211—217, pl. xii. fig. 14; and especially Palæontographical Monograph, 1850, p. 51, *et seq.*; and plates xii. to xvi.

the Hordwell vertebræ to those of the recent *Eryx*, one of the Boa and Python group of serpents.*

The vertebræ of Serpents are distinguished by a transversely oblong anterior concavity, forming a deep cup, and a corresponding posterior convexity or ball; by the interlocking of the projecting posterior oblique processes with the anterior pair; and by the oblong tubercle on each side of the anterior part of the body of the vertebra, for moveable articulation with the head of the ribs; a spinal column thus constructed combines in the highest degree perfect flexibility with great strength.

In addition to the ophidian relics above referred to, fossil vertebræ of a small serpent (*Palæophis?*) have been found in the Eocene sand below the Red Crag, at Kyson in Suffolk;† a locality that has yielded other organic remains of great interest (see chap. xix.; and *Wond.* p. 258). The only fossils of this order of reptiles known to Baron Cuvier appear to have been some vertebræ from the bone-breccia of Cette (*Oss. Foss.* tom. iv. p. 177).

Fossil eggs of snakes are occasionally met with in a comparatively recent limestone, of fresh-water origin, in Germany, near Offenbach, associated with shells of land and freshwater molluscs. Like the turtles' eggs on the shores of Ascension Island, these ova were probably laid in the moist mud, and became encrusted and preserved by a deposit of tufa.‡

VIII. BATRACHIANS.—The reptiles termed BATRACHIANS (from the Greek name for Frog) are characterized by the metamorphoses which they undergo in the progress of their development from the young to the adult state; the Frog,

* See Monograph on Eocene Reptiles, 1850, from which these notices of the Eocene Ophidians are abridged.

† Rep. Brit. Assoc. 1841, p. 181; and Monograph, 1850, p. 66.

‡ Quart. Journ. Geol. Soc. vol. vi. part 2, p. 42.

Toad, and Newt are familiar examples of this order. Their organs of aërial respiration consist of a pair of lungs; but in their young state they are provided with gills, supported, as in fishes, by cartilaginous arches. These organs disappear, in most species, when the animals arrive at maturity; but in a few genera, as the *Siren* and *Proteus,* they are persistent. The skeletons of these reptiles present corresponding modifications. The skull is, for the most part, much depressed, and the cerebral cavity small; it is united to the vertebral column by *two* distinct condyles, situated on the sides of the occipital or cranio-spinal aperture.* The vertebral column, in some genera (as, for example, in the common frog), is very short, and is reduced to eight or ten bones, the caudal vertebræ being fused into a long cylindrical style; but in the higher organised Batrachians the spine is composed of concavo-convex vertebræ, as in the Crocodile: in the lower type, as the Siren, Proteus, and Axolotl, the vertebræ are biconcave, as in numerous species of fossil Saurians. The ribs are merely rudimentary, being very short and few; a condition which has relation to the mode of reproduction in these animals, the eggs being accumulated and shed at once.† Some of the Batrachians are edentulous, but others have numerous small, conical, uniform, closely-arranged teeth, placed either in a single row, or aggregated like the rasp-teeth in fishes.‡

BATRACHOLITES; or fossil remains of Batrachians.—The skeletons, vestiges of the soft parts, and imprints of the feet of several genera of Batrachians occur in a fossil state in tertiary deposits, all of which, like the existing races, appear to belong to fresh-water or terrestrial species. In the pliocene or newer tertiary strata, on the banks of the Rhine, at

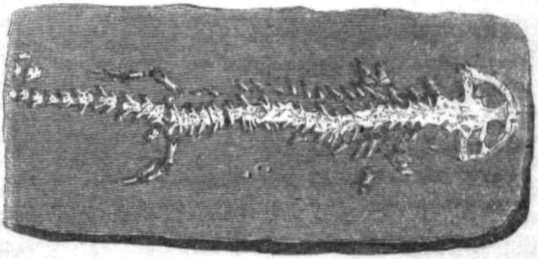
* Saurians, like birds, have a single occipital condyle.

† See Dr. Roget's *Bridgewater Essay*, p. 395.

‡ The variations in the dental system of these animals are given in *Odontography*, chap. ii. p. 187.

Œningen, and in the *papierkohle* of the Eifel, several species of Frog, Toad, and Newt, have been discovered. Fossil frogs of a small species, very similar to the recent, occur in numbers in a dark shale, overlaid by basalt, in the vicinity of Bombay.*

A celebrated fossil of this class is the gigantic Salamander (*Cryptobranchus*), three feet in length (*Lign.* 243), found at Œningen (see *Wond.* pp. 263, 580), which a German physician of some note (*Scheuchzer*) supposed to be a



LIGN. 243. CRYPTOBRANCHUS SCHEUCHZERI: $\frac{1}{11}$ *nat. size.*
Tertiary. Œningen.

fossil man ! † and he described it in an essay, entitled "*Homo diluvii testis et Theoscopos*," as being the moiety, or nearly so, of a human skeleton, with the bones and flesh incorporated in the stone.‡ A fine example of this fossil Salamander is preserved in the British Museum (*Petrif.* p. 186).

LABYRINTHODON. *Ly.* p. 290—293 ; *Wond.* p. 550.—By far the most interesting evidence of the existence of Batrachian reptiles in the earlier ages of our planet has been afforded by Professor Jäger's discovery of the skull, teeth, and other remains of gigantic extinct animals, allied to the

* Quart. Geol. Journ. vol. iii. p. 221.

† Phil. Trans. for 1726, vol. xxxiv.

‡ Ample description and figures of this highly interesting fossil are given by Cuvier, *Oss. Foss.* tom. v. part ii. p. 431, pl. xxv. xxvi.

Salamander, in the Upper New Red Sandstone (*Keuper*) of Wirtemberg.*

These remains were referred by this eminent physician and naturalist to saurian genera, although the double condyle of the occipital bone indicated Batrachian affinities. It was reserved, however, for our distinguished countryman, Professor Owen, to correct the error into which the German *savant* had fallen,—remove the obscurity in which the subject was involved,—determine the natural relations of the original,—and develope a modification of dental organization of the most unexpected and interesting character.

Dr. Lloyd, of Leamington, having discovered some fossil teeth and bones in the light-coloured sandstone of the New Red, at Warwick and Leamington, submitted them to Professor Owen, who, struck with their general resemblance to the teeth of the gigantic *Salamandroïdes* of Wirtemberg, instituted a microscopic examination of the British and German specimens. The result proved that the teeth from both localities possessed a remarkable and complicated structure, produced by the convergence of numerous inflected folds of the external layer of cement towards the pulp-cavity; to which, as we have already seen (p. 666), a very slight approach was made in the tooth of the Ichthyosaurus, and a still closer approximation by the teeth of certain fishes (*Lepidosteus*, p. 616). From the intricate meanderings or labyrinthine inflections observable in the sections of these teeth, Professor Owen has given the name of *Labyrinthodon* to these extinct Batrachian reptiles, and has determined five British species; one of which (*L. Jægeri*) he conceives to be identical with a species described by my friend, Dr. Jäger.

* Über die Fossile Reptilien welche in Würtemberg aufgefunden worden sind, von Dr. Geo. Friedr. Jäger. 4to. Stuttgart, 1828. See also Hermann von Meyer's Notice of the Saurians of the Muschelkalk, Bunter Sandstein, and Keuper, *Quart. Geol. Journ.* vol. iv. pt. ii. p. 40.

The remains of the skeletons of these reptiles, hitherto found in Warwickshire, consist of portions of the cranium, and of the upper and lower jaws, with teeth, vertebræ, a sternum, and some of the bones of the pelvis and the extremities. From a specimen (of *L. scutulatus*) consisting of an aggregated group of bones, imbedded in sandstone, comprising four vertebræ, portions of ribs, a humerus, a thigh-bone, and two leg-bones, with several small *osseous scutes*, it appears that one species, at least, resembled the Crocodiles in its dermal structure. But Professor Owen remarks, that this modification of the dermal system does not affect the claims of the Labyrinthodonts to be considered as Batrachians, although all the known living species of this order are covered with a soft, lubricous, naked integument; for the skin is the seat of the most variable characters in all animals; and the double occipital condyle, the simple lower jaw, the palatal vomerine bones, and the teeth of these fossil reptiles must be deemed decisive of their essentially Batrachian nature.

From the specimens of the cranium the important fact has been ascertained, that the Labyrinthodonts had subterminal nostrils leading to a wide and shallow nasal cavity, which is separated by a broad and almost continuous palatal flooring from the cavity of the mouth; indicating, by its horizontal position, that the posterior apertures were placed far behind the external nostrils; whereas in the recent air-breathing Batrachians the nasal canal is short and vertical, and the inner apertures pierce the anterior part of the palate. The nasal cavities in the Frog are vertical; for this reptile *swallows* air. The Labyrinthodonts must, therefore, have breathed air like the Crocodiles, and were probably provided with well-developed ribs, and not mere rudimentary styles, as in most living Batrachians.

Tooth of the Labyrinthodon. *Pl. VI. fig.* 3. — The tooth of the Labyrinthodon is of a conical figure, very

slightly recurved, and marked externally with shallow, fine, longitudinal striæ. *Pl. VI. fig.* 3[a], represents (½ *nat. size*) a specimen presented to me by Dr. Jäger. The tooth is implanted, by a single fang, in an alveolar groove to which it is anchylosed. It consists of a simple central pulp-cavity, surrounded by a body of dentine, which has an external thin coat of cement; and a vertical duplication or fold of this cement penetrates the substance of the tooth at each of the striæ, which are arranged at intervals of about one line around the entire circumference of the tooth. The inflected folds of cement extend inwards towards the centre, in a straight direction for about half a line, then become undulated, and finally terminate in a dilatation or loop, close to the pulp-cavity, from which it is separated by a thin layer of dentine. Within these inflections of the cement, the dentine, or tooth-bone, is similarly disposed; a layer of dentine lining the folds of cement, and having corresponding interspaces, which are filled up by the processes from the pulp-cavity. It is this blending of the cement and dentine in labyrinthine folds, that gives the peculiar character observable in transverse sections of the teeth. *Pl. VI. fig.* 3[a], represents a transverse section of half the diameter of the tooth; the vacancy in the middle of the line at the bottom is a section of half the pulp-cavity. *Fig.* 3[b] is a vertical section of a fragment near the summit of the tooth; and *fig.* 3[c], a highly-magnified view of one of the anfractuosities, showing a fold of cement, surrounding a fold of dentine, and in the centre of the latter the termination of a process of the pulp. The section of the tooth of the Ichthyosaurus, *Pl. VI. fig.* 9, shows the most simple modification of this structure; the apparent complication of that of the Labyrinthodon arises from the inflections of the three elements of dental organization being more numerous and diversified. But the beautiful plates and the graphic description of the original discoverer must be seen and perused to obtain an

adequate idea of the exquisite structure of the fossil teeth; for the distribution of the extremely minute calcigerous tubes of the dentine is as diversified as that of the constituent substances. And even after viewing these *chefs-d'œuvres* of structural delineations, should the reader have an opportunity of examining a transverse section of a tooth under the microscope, he will feel how feebly any engraving can represent the characters of the original.*

ARCHEGOSAURUS. *Lign.* 244, *Ly.* p. 336, figs. 384,† 385. —The occurrence of reptilian remains in deposits of higher antiquity than the Triassic was first established in 1844, by the discovery of the skull and other portions of the skeleton of an air-breathing reptile, the *Apateon pedestris*, related to the Salamanders, and about three feet in length, in the coal of Münster-Appel in Rhenish Bavaria. In 1847 Professor Von Dechen obtained, in nodules of argillaceous ironstone, from the coal-field of Lebach, in the district of Saarbrück, three species of the same type of reptiles; these have been described by Goldfuss, under the name of *Archegosaurus*.‡ One of them was well known to collectors, but had previously been regarded as a fish (the *Pygopterus lucius* of M. Agassiz).

The skull and portions of the trunk of this species (*A. Dechenii*), see *Lign.* 244, indicate an animal three and a half feet in length. Seventeen dorsal vertebræ, imprints of the ribs, and remains of the extremities, have been col-

* Professor Owen's Memoir on the Labyrinthodonts, in *Geol. Trans.* 2d ser. vol. vi. pp. 503—543, with five admirable lithographs by that excellent artist, Mr. Scharf, and the description of the structure of the teeth, *Odontography*, p. 195, pl. lxiii. lxiv. should be consulted. See also *Cyclop. Anat.* Art. TEETH.

† The original of this figure of *Archegosaurus minor* is now in the British Museum.

‡ See a notice of the researches of Goldfuss, Von Dechen, and Von Meyer in the geological and zoological history of this interesting group of batrachoid reptiles, *Quart. Journ. Geol. Soc.* vol. iv. part ii. (Miscell.) p. 513, *et seq.*

lected. The jaws to beyond the orbit have small fine conical teeth, longitudinally striated. The eye was furnished with an osseous ring. The skin, of which a considerable part was detached, was covered by long, narrow, wedge-shaped, horny scales, arranged in rows (*Lign.* 244). The cranial bones are characterized by reticulating grooves and pittings, similar in character to the reticulate markings on the cranial bones of the Labyrinthodon, but of a more delicate sculpturing. The original reptiles were quadruped; the fore and hind feet had distinct toes; but the limbs were feeble, and only capable of swimming, or, when on land, of a slow creeping movement.

The Archegosaurus is closely allied to the Labyrinthodonts;* and, in the words of Professor Owen,† it is "essentially Batrachian, and most nearly allied to the perennibranchiate, or lowest or most fish-like of that Order of Reptiles."

PARABATRACHUS COLEI.—Under this appellation Professor Owen has lately described (*Quart. Geol. Journ.* vol. ix. p. 67, pl. ii. fig. 1,) a batrachoid fossil, consisting of cranial and maxillary bones with teeth, probably from the shale of the Glasgow coal-field, at Carluke, Lanarkshire. The slab of coal-shale in which the specimen is imbedded contains also a large scale of the *Holoptychius* (see p. 618).

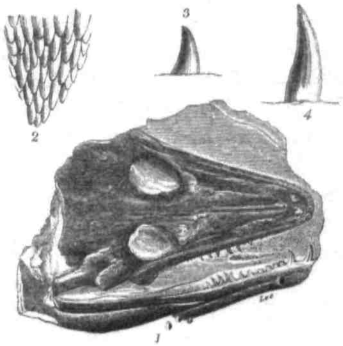
DENDRERPETON ACADIANUM.‡ (*Quart. Journ. Geol. Soc.*

* We may remark that in the opinion of Dr. Goldfuss and Von Meyer (*loc. cit.*) the Labyrinthodon and the Archegosaurus are saurian forms connecting the Crocodiles and the Lizards, and representing in the ancient fauna an arrested or "permanent larva-condition of the loricated reptiles, as the sirens do among the recent batrachians." Professor Owen's estimation of the affinities of these genera is stated above, and in the *note* at p. 55, Geol. Journ. vol. iv. part ii.

† Quart. Geol. Journ. vol. ix. p. 69.

‡ The *Tree-reptile of Acadia* (Acadia being the ancient Indian name fo Nova Scotia).

1853, pp. 58—67, plates ii. and iii.)—The remains of a reptile and a land-shell, resembling a *Pupa*, were discovered in 1852, by Sir C. Lyell and Mr. J. W. Dawson, in the interior of an erect stump of a fossil tree (*Sigillaria*), in



LIGN. 244. ARCHEGOSAURUS DECHENII. ½ *nat. size.*
Coal Formation. Saarbrück.
Fig. 1.—The cranium and part of the lower jaw.
2.—A portion of the skin, or dermal scutes, magnified.
3 and 4.—Magnified figures of two teeth.

the coal-measures at the South Joggins cliffs, Nova Scotia. These remains were fully described by Professor Jeffries Wyman, of Harvard University, U. S., and Professor Owen in the Appendix to the Memoir by Sir C. Lyell and Mr. Dawson, in the Journal of the Geological Society, vol. ix. Some of the bones were recognised as having a near resemblance to those of the recent *Menobranchus* and *Menopoma* (Perennibranchiate Batrachians, inhabiting North American fresh-waters); the sculptured cranial bones are analogous to those of the *Labyrinthodon* and *Archegosaurus;* and the teeth have a Labyrinthodontoid structure: numerous, small, concentrically striated scutes, of an irregular oval shape, accompany the bones and teeth.

The conclusions arrived at by the eminent comparative anatomists to whose examination the remains in question were submitted, show that the character of the fossils are those of Perennibranchiate Batrachians; that, with regard to the long bones, it is not improbable that the corresponding bones in the *Archegosaurus* (p. 745) and *Labyrinthodon* (p. 741) would present similar correspondences with those of the existing perennibranchiates; and that, although the *Dendrerpeton* cannot be referred to any known form of the two genera just mentioned, yet there exists strong evidence of its close affinity with these extinct Batrachians.

The *Dendrerpeton Acadianum* was probably between two and three feet in length. A series of minute biconcave vertebræ were found with the other remains in the erect tree; these, however, from their relatively small size, and from other characteristics, are regarded by Professor Wyman as having probably belonged to some other associated reptile.

The Labyrinthodont reptiles have been regarded as characteristic of the Permian and Triassic epochs, their remains being found in Germany and England in rocks of that age. The commencement of the existence of this family of sauroid-batrachians, however, is of greater antiquity, since their relics also occur in the formations of the Carboniferous epoch. The *Archegosaurus* (p. 745), a batrachian but slightly removed from the true Labyrinthodont type, has left its well-characterized remains in the Coal of Germany; the *Parabatrachus*, in that of Scotland; and the allied *Dendrerpeton*, in the Nova Scotian coal-field. This last-mentioned great carboniferous formation has, however, afforded fossil evidence of the existence of the true Labyrinthodonts in the Coal-period; for some cranial bones, imbedded in a mass of Pictou coal, lately sent to England by Mr. J. W. Dawson, and the subject of a Paper by Professor Owen, read before the Geological Society, were

demonstrated by that distinguished palæontologist to have close affinity with the corresponding parts of the skull of the Triassic genera *Capitosaurus* and *Metopias*.

ICHNOLITES (*Foot-prints on stone*). *Lign.* 245.—The sandstones and mud-stones of many localities retain the track-prints of animals that have passed along on the surface of the beds when in a soft state. These foot-prints, or *ichnolites*, either occur as impressions on the surface originally marked by the animal in the act of progression, or as the reverse of such impressions, being casts *in relief* on the under side of the layer covering the surface originally impressed. Such indications of footsteps and trails have been noticed especially in the forest marble, a member of the Lower Oolite series, where Crustacea and Mollusks have left their markings, and in the New Red Sandstone, where the indications of reptilian quadrupeds and of bird-like bipeds* have been here and there preserved in great distinctness. Tracks referable to Crustaceans have been found by Mr. W. E. Logan, on the very ancient and rippled surfaces of the Potsdam Sandstone of North America (see p. 543, *note*); and very lately Mr. J. W. Salter has communicated to the Geological Society the discovery of markings, referred by him to the little entomostracous Hymenocaris (see p. 526), on the Lower Lingula Flags of North Wales,—deposits of as great an age, if not older. The most ancient *reptilian* ichnolites are those discovered by Capt. L. Brickenden† in the Old Red, at Cummingston, near Elgin, which have some resemblance to the track of a club-footed Chelonian (*Ly. fig.* 521); and those of the Devonian sandstone of Sharp Mountain, Pennsylvania, discovered by Mr. I. Lea,‡ which

* See ORNITHOIDICHNITES, in chap. xviii.

† Quart. Geol. Journ. vol. viii. p. 97, pl. iii.

‡ Across the ridges of the ripples on this slab is a narrow groove, passing along between the two rows of foot-prints; this might have

exhibit distinct toes, and are probably allied to the Cheirotherian ichnolites, about to be mentioned, as are also other ancient fossil foot-tracks in the Carboniferous deposits* of Pennsylvania, which are figured and described in *Ly.* pp. 337—340.

The sandstones of the New Red or Triassic series frequently retain the track-prints of animals, and numerous notices of such occurrences have been published.† In addition to the account of these invaluable evidences of the existence of bygone creatures that is here given, the attention of students is especially directed to Dr. Buckland's most interesting description and illustrations of such as were known when his Treatise was published (*Bd.* i. p. 259, &c ; and ii. p. 36, pl. xxvi. &c.).

The imprints of the feet of some large quadrupeds, having the fore-paws much smaller than the hinder, have been found in Saxony (see *Wond.* p. 555, *Bd.* p. xxvi.'); and also in strata of the same age in Warwickshire and Cheshire.

been made by the body or the tail of the animal. *Rep. Brit. Assoc.* 1849, Sect. pp. 56 and 134; and *Trans. Americ. Phil. Soc.* new series, vol. x. part ii. plates xxxi. and xxxii.

* With regard to the distribution of reptilian life during the carboniferous and succeeding epochs, see above, page 748.

† The following are the principal notices of ichnolites by English authors which are not referred to in the text:—Cunningham, Yates, and Egerton on Cheirotherian traces in Cheshire, *Geol. Proc.* vol. iii. pp. 12—15; Dr. Black on foot-prints at Runcorn, *Quart. Geol. Journ.* vol. ii. p. 65, pl. ii.; Mr. Cunningham, *Liverpool Lit. and Phil. Proc.* 1848, p. 129, plates iii.—v.; Mr. Hawkshaw on the New Red with foot-prints at Lymm, *Rep. Brit. Assoc.* 1842, Sect. p. 56; Mr. Rawlinson on the same, *Quart. Geol. Journ.* vol. ix. p. 37; Prof. Harkness on the track-bearing beds of Dumfriesshire, *Rep. Brit. Assoc.* 1850, Sect. p. 83; *Quart. Geol. Journ.* vol. vi. pp. 389 and 393; and *Annals Nat. Hist.* 1850, vol. vi. p. 203; Sir W. Jardine, *Annals Nat. Hist. loc. cit.* Foreign authorities may be found by reference to Pictet's *Traité de Paléontologie*, a new and enlarged edition, vol. i. 1853, p. 567, *et seq.*

The quarries at Storeton Hill, near Liverpool, are celebrated for the abundance and variety of these imprints.* Some of the strata of sandstone in this locality are divided by thin beds of clay; a lithological structure which admits of the ready separation of the stone in the direction of the sedimentary planes.

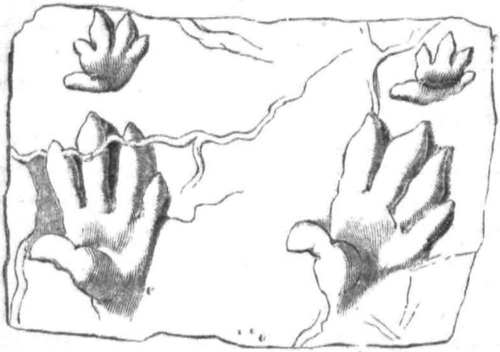
Imprints are found on the face of each successive stratum; and on some of the layers, not only the tracks of animals that have walked over the clay when soft are distinctly observable, but the surface is often traversed with casts of the cracks caused by the desiccation of one layer of clay previously to the deposition of the succeeding layer of sand or mud; and it often presents a blistered or warty appearance, being covered with either little hemispherical eminences or depressions, which an accurate investigation of the phenomenon has proved to have been produced by showers of rain (*Ly.* figs. 526—528). On the slabs of sandstone, the forms of the sun-cracks, rain-drops, and foot-prints appear in relief, being casts moulded in the soft clayey mud upon which the original impressions were made; while on the clay or shale, corresponding depressions are apparent.†

The foot-prints on these strata are of several kinds; some appear to have been produced by small reptiles and crustaceans; but the principal imprints are identical with those which have been observed in Saxony, and are referable to some large quadruped, in which the fore-feet were of a much

* The Museums at Warwick, Warrington, and Liverpool are rich in impressed slabs from the Triassic districts. Numerous fine specimens may be also seen in the Museum of the Geological Society, Somerset House, the Museum of Practical Geology, in Jermyn Street, and in the British Museum (see *Petrif.* pp. 14 and 63).

† The impressions of rain-drops on stone were first noticed, and their origin explained, by Mr. Cunningham. *Geol. Proc.* vol. iii. p. 99. See also an interesting Paper by Sir C. Lyell, *Quart. Geol. Journ.* vol. vii. p. 240.

smaller size than the hind-feet (*Lign.* 245). From a supposed resemblance of the imprints to those of a human hand, Professor Kaup proposed the name of *Cheirotherium*, to designate the unknown animal which had left these



1 2

LIGN. 245. CHEIROTHERIUM KAUPII. $\frac{1}{8}$ *nat size.*

Casts of the foot-marks of a gigantic extinct Batrachian, probably a Labyrinthodon; with casts also of the cracks of the opposed surface.

Trias. Hessburg, near Hildburghausen, Saxony.

Fig. 1.—Casts of the imprints of a hind and a fore-foot of the same animal.
2.—Similar tracks of another individual on the same stone.

"footsteps on the sands of Time." But since Professor Owen's discovery, that the bones and teeth of reptiles found in similar strata in Warwickshire belong to gigantic Batrachians, and since the fore and hind-feet of the frog-tribe are often as dissimilar in size as the impressions of the *Cheirotherium*, it has been suggested, with much probability, that the foot-prints in question may be those of Labyrinthodonts; but until the form of the feet of these extinct Batrachians can be ascertained, this inference must be regarded as conjectural (*Ly.* fig. 331).

Allusion has already been made to foot-prints, supposed to be those of tortoises (see p. 729), on slabs of Triassic

sandstone in Scotland. Of these there are five species at Corncockle Muir, in Dumfriesshire: they are termed *Chelichnus* by Sir W. Jardine, who has lately described them in his *Ichnology of Annandale*, a splendid folio work, illustrated with full-sized lithographs, coloured after nature. They are accompanied with three other forms of footstep (*Herpetichnus*, *Batrachnis*, and *Actibatis*), one of which Sir W. Jardine regards as indicative of an animal probably of a saurian form.

At Grinshill quarry, from which the remains of the *Rhynchosaurus* (p. 712) were obtained, some small foot-prints have been observed, which, with some probability, have been referred to that animal (*Rep. Brit. Assoc.* 1841, p. 146).

A beautifully distinct series of foot-prints, with the mark of a trailing tail, on a rippled slab from the New Red of Shrewley Common, Warwickshire, are figured and described by Strickland and Murchison (*Geol. Trans.* 2d ser. vol. v. pl. xxviii.). This ichnolite has been provisionally assigned by Professor Owen to *Labyrinthodon leptognathus*.* Similar impressions occur in company with other Cheirotherian imprints at Storeton Hill and at Grinshill.

On Collecting the Fossil Remains of Reptiles.—The length to which this article has extended, compels me to omit a retrospect of the geological distribution of fossil reptiles; and I must refer the reader to the brief review of the Age of Reptiles in *Wond.* p. 568, *et seq.*, and *Petrif.* p. 147, &c., and close this chapter with some directions for collecting reptilian remains, and a list of a few British localities.†

* Geol. Trans. 2d ser. vol. vi. p. 525. The probable relations of *Cheirotherium Hercules* to *Labyrinthodon Jægeri*, and of *Ch. Kaupii* to *L. pachygnathus*, are pointed out by the same high authority, *ibid.* pp. 537, 538.

† An able Summary on British Fossil Reptiles is appended to Prof. Owen's Report, *Rep. Brit. Assoc.* 1841, p. 191.

The fossil *Teeth of Reptiles* are commonly found in as perfect a state of preservation as those of fishes; and require but the usual care for their preservation. But the collector should assiduously search for vestiges of the jaw and cranium; and it is desirable to place in the same drawer any undetermined bones found associated with the teeth; as they may ultimately afford some clue to the nature of the original animal. The microscopical examination of the teeth is to be conducted in the manner previously directed (p. 639); but for valuable specimens the lapidary should be employed, and transverse sections made from near the apex, the middle, and base of the tooth; if due care be taken, several slices may be obtained from one specimen. I have ten slices from one tooth of the Labyrinthodon. The bones imbedded in limestone generally partake of the chemical character of the rock, and are often permeated with calcareous spar; mere fragments, when polished, frequently display the internal structure.

The suggestions for repairing fossil bones (p. 46) render further instructions on that head unnecessary; and the description of the development of the specimen of Hylæosaurus (p. 689) affords a practical lesson to the young collector.

When a vertebra is found in an imperfect state, it should be closely examined on the spot, and, if it present proofs of recent fracture, the detached processes should be sought for; even if the body of a vertebra be imbedded in stone, and the processes appear to have been broken off before it was enveloped in the rock, the corresponding parts will often be found in the same mass of stone. There is in the British Museum a very fine Saurian vertebra imbedded in a large slab of Tilgate stone, in which the spinous process is seen lying in the same block, several inches distant from the centrum or body; when observed in the quarry the latter only was exposed, and I was about to detach it from the

slab, for the convenience of carriage, when I perceived indications of the spinous process. The vertebra was therefore allowed to remain, and the stone chiselled away, so as to expose the spine; and the specimen then displayed its present interesting character.

It may frequently happen that a fragment of a large bone,—as, for example, the thigh-bone of the Iguanodon,—may be obtained from a quarry; and after an interval of some weeks the corresponding portions be discovered. This was remarkably exemplified in the first specimen which revealed to me the peculiar characters of the femur of the Iguanodon. The lower part, or condyloid extremity, of a gigantic bone, firmly impacted in a block of Tilgate-grit, was found in a quarry near Cuckfield; it was evidently but a fragment of the fossil, for the fracture was recent; I therefore requested the quarry-men to make diligent search for the corresponding portion, but without success. Several months afterwards, upon a fresh explosion in the quarry, the head of a large bone was found loose among the fallen mass; but there were no indications that it belonged to the specimen previously found; and it was regarded as another relic of some one of the colossal animals whose bones were distributed in the Wealden deposits. Teeth, fragments of bones, and other fossils were from time to time obtained from the same quarry; and among these a huge quadrangular fragment of bone, similar to the enormous mass that had so long been in my possession, and had defied all attempts to ascertain its character.* It was some time before it occurred to me, that the three portions of unknown colossal bone might belong to the same specimen; but eventually they were found to correspond, and upon cementing them together, the femur of the Iguanodon was, for the first time, developed.

The figures in *Lign.* 206 will assist the collector in

* The fragment alluded to is figured, *Foss. Til. For.* pl. xviii.

recognising the different vertebral processes, even when occurring as detached fragments. When specimens are evidently rolled or water-worn, there is, of course, no probability that the corresponding portions will be met with. Every fragment of a bone the nature of which is not obvious should be carefully preserved; for sooner or later its characters may be ascertained. It is scarcely necessary again to remind the collector, that search should be made for indications of the soft parts around the bones; the specimen of the paddle of the Ichthyosaurus (*Lign.* 215, p. 669), with its integument, must have impressed this fact too strongly on the mind to be soon forgotten. If the impression of the extremities of a bone, of which a fragment only remains, be observed, the block of stone should be preserved, as a cast may be taken, and the entire form of the original be ascertained.

BRITISH LOCALITIES OF FOSSIL REPTILES.

Aust Cliff, near Bristol. *Lias.* Plesiosaurus.

Barrow-on-Soar. *Lias.* Ichthyosaurus, Plesiosaurus.

Bath. *Lias.* Plesiosaurus.

Battle, Sussex. *Wealden.* Iguanodon, Cetiosaurus, Goniopholis, Chelonians.

Binstead, Isle of Wight. *Upper Eocene.* Fresh-water Tortoises.

Bognor. *Lower Eocene.* Chelone.

Bolney, Sussex. *Wealden.* Hylæosaurus, Iguanodon, Chelonia, Goniopholis.

Bracklesham Bay. *Middle Eocene.* Crocodiles, Serpents, Chelonians.

Brighton. *Chalk.* Vertebræ of Mosasaurus or Leiodon.

Bristol. *Lias.* Ichthyosaurus.

Brook-Point, Isle of Wight. *Wealden.* Iguanodon, Cetiosaurus, &c.

Burham, near Maidstone. *Chalk.* Chelone, Dolichosaurus, Pterodactylus.

Burwash, Sussex. *Wealden;* quarries in the neighbourhood. Goniopholis, Turtles.

Cambridge. *Lower Chalk.* Raphiosaurus, Polyptychodon.

Charmouth. *Lias.* Ichthyosaurus.

Cheltenham. *Lias.* Ichthyosaurus.

Chipping Norton. *Oolite.* Streptospondylus.

Clayton. *Chalk.* Coniosaurus.

Corn-Cockle Muir, Dumfries. *New Red.* Imprints of feet of Reptiles.

Coton-End, Warwickshire. *New Red.* Labyrinthodon, &c.

Cubbington, Warwickshire. *New Red.* Labyrinthodon.

Cuckfield. *Wealden;* quarries in the vicinity. Iguanodon, Pelorosaurus, Hylæosaurus, Trionyx, &c.

Culver Cliff, Isle of Wight. *Wealden.* Streptospondylus.

Dover. *Chalk.* Ichthyosaurus, Plesiosaurus.

Garsington, Oxfordshire. *Oolite.* Cetiosaurus.

Glastonbury. *Lias.* Ichthyosaurus.

Grinsill, Warwickshire. *New Red.* Rhynchosaurus.

Guy's Cliff, Warwick. *New Red.* Labyrinthodon.

Harwich. *London Clay.* Chelonia.

Hastings. *Wealden.* Iguanodon, Pelorosaurus, Goniopholis, Turtles.

Hordwell. *Middle Eocene.* Crocodiles, Chelonians, Serpents.

Horsham, Sussex. *Wealden;* quarries in the vicinity. Hylæosaurus, Iguanodon, Goniopholis, Turtles, &c.

Heddington, Oxfordshire. *Kimmeridge Clay.* Pliosaurus.

Ilminster. *Upper Lias.* Ichthyosaurus, Teleosaurus.

Kyson, Suffolk. *Eocene.* Serpent, Lizard.

Leamington. *New Red.* Labyrinthodon.

Lewes. *Chalk.* Vertebræ of Mosasaurus or Leiodon.

Lyme Regis. *Lias.* Pterodactyles, Ichthyosauri, and Plesiosauri in abundance.

Maidstone. *Lower Green Sand;* quarries near the town; particularly Mr. Bensted's "*Iguanodon quarry.*" Iguanodon, Plesiosaurus, Polyptychodon, Fresh-water Tortoise.

Malton. *Oolite.* Megalosaurus.

Market Rasin. *Kimmeridge Clay.* Pliosaurus.

Norfolk? *Chalk.* Leiodon: *very rare.*

Portland, Isle of. *Oolite.* Turtles.

Purbeck, Isle of. *Purbeck.* Goniopholis, Chelonians. *Kim. Clay.* Pliosaurus.

Redland, near Bristol. *Magnesian Conglomerate.* Palæosaurus, Thecodontosaurus.

Saltwick. *Lias.* Teleosaurus.

Sheppey, Isle of. *London Clay.* Turtles, Serpents, Crocodiles.

Shotover, near Oxford. *Kimmeridge Clay.* Pliosaurus, Teleosaurus.

Southerham. *Chalk.* Mosasaurus, Plesiosaurus.

Stonesfield. *Oolite.* Megalosaurus, Teleosaurus, Pterodactyles.

Stourton, Cheshire. *New Red.* Foot-prints of reptiles (*Cheirotherium*), &c.

Street, Somersetshire. *Lias.* Ichthyosauri and Plesiosauri.

Swanage, Isle of Purbeck. Goniopholis, Chelonians.

Tilgate Forest. *Wealden;* quarries in various localities. Iguanodon, Megalosaurus, Hylæosaurus, Suchosaurus, Turtles, and Tortoises.

Watchet, Somersetshire. *Lias.* Plesiosauri, Ichthyosauri.

Warwick, Guy's Cliff, near. *New Red.* Labyrinthodon.

Westbrook, Wilts. *Kimmeridge Clay.* Ichthyosaurus.

Weston, near Bath. *Lias.* Plesiosaurus.

Whitby, Yorkshire. *Lias.* Ichthyosauri, Plesiosauri, Teleosaurus.

Wight, Isle of; along the southern shore, near Brook-point. *Wealden.* Iguanodon, Cetiosaurus, &c., washed up on the sea-shore.

CHAPTER XVIII.

ORNITHOLITES; OR FOSSIL BIRDS.

Excepting in strata of comparatively modern origin, the remains of Birds are of extreme rarity in a fossil state. In the caverns that contain the skeletons of carnivorous animals, and which in many cases were once their dens, the bones of several species of existing genera of Birds have been discovered, in England, on the Continent, in America, and in Australia; and recently there have been obtained from alluvial deposits in New Zealand the skeletons of Birds, some of enormous magnitude, and under conditions which leave some doubt whether, like the *Dodo*, the species may not have been extirpated by man during the last few centuries; or even if some stray individuals of the race may not, according to the belief of the aborigines, be still in existence in the interior of the country.

From the gypsum quarries at Montmartre, near Paris, Baron Cuvier obtained several species of Ornitholites; and Prof. Owen has described the relics of three or four species from the London Clay: these fossil birds of the eocene tertiary deposits are the most ancient relics of this class known to the geologist, with the exception of the foot-prints on the *New Red* sandstone of North America, that have been referred to animals of this class.

The rarity of the remains of Birds may probably in some measure be attributable, as Sir C. Lyell has suggested, to the peculiar organization of these animals; for their power

of flight necessarily renders them less liable to be engulphed and imbedded in the deltas of rivers or in the bed of the ocean, than quadrupeds; and the lightness of their structure, occasioned by their tubular bones and feathery dermal integument, generally prevents the sinking of the bodies of such as die on, or fall into, the water; so that their carcases are devoured or decomposed.

In illustration of this subject, I purpose, in the *first* place, to explain such peculiarities in the osteology of the animals of this class, as may assist the collector in the identification of their fossil remains; *secondly*, to take a cursory survey of the geological distribution of fossil BIRDS, and examine a few of the most interesting examples; and *lastly*, consider the striking phenomena presented by the foot-prints of supposed Birds on the strata of those ancient deposits which are comprised in the *Trias* or New Red formation.

I. OSTEOLOGICAL CHARACTERS.—The skull in adult birds presents this remarkable feature, that it is composed of but one bone without any trace of suture: the osseous tissue is very compact; *the bone is white, and very smooth externally.* The lower jaw is formed, as in reptiles, of several bones, namely, articular, angular, supra-angular, and dental; it is united to the skull by the intervention of a bone (*os quadratum*), as in certain reptiles. Both jaws are destitute of teeth, and are protected by dense horny sheaths, which form powerful dentary organs. The vertebral column of the neck is exceedingly flexible, and is composed of a greater number of bones than in any other living animals; for the cervical vertebræ, which in the mammalia amount to seven, in birds vary from ten to twenty-four, as in the Swan. To admit of this extreme mobility of the *neck* without injury to the enclosed spinal cord, the annular part, or neural arch, of each cervical vertebra is enlarged at the extremities that form a junction with the corresponding bones; thus pre-

senting a modification of vertebral development directly the reverse of that possessed by the extinct saurian of the Magnesian conglomerate (see p. 714). The dorsal and sacral vertebræ, on the contrary, are firmly interlocked, and often anchylosed together, and constitute a strong, inflexible pillar, to afford a fixed point of support to the powerful locomotive organs of flight. There are no *lumbar*, or ribless vertebræ. The sacrum often consists of eighteen, twenty, or more vertebræ, anchylosed into a solid bone. In the young Ostrich the vertebræ may be found separate and distinct; and the neural arch is shifted to the union of two vertebræ, as in the *Megalosaurus*. The sacral spinal cord is almost as large as the brain; to supply the large muscles. The foramina for the passage of the nerves are double, one for the sensitive, and the other for the motive root, which pass out separately and unite in a ganglion externally. The ribs are formed so as to combine strength with lightness in the construction of the walls of the chest, for each rib has a *recurrent apophysis*, or process, that extends backwards, and glides over the contiguous bone; this is a very peculiar and obvious character.* The ribs are united in front to the sternum by bony processes, analogous to the *costal-arcs* of the Plesiosaurus. The pectoral arch is distinguished by the prominent longitudinal keel or crest of the sternum; a structure designed to give attachment to the powerful pectoral muscles which move the wings, and which presents characteristic modifications in the different orders; and by the peculiar bone, termed the *furcula*, or merry-thought, which connects the clavicles. The clavicles are strongest and most open in birds of strongest flight. The coracoids (in birds) relate to respiration, and serve to admit of contraction and expansion of the sternum and abdomen. The bones of the anterior extremities are modi-

* In very old crocodiles an analogous apophysis, which is generally cartilaginous, is sometimes found ossified (*Owen*).

fied to adapt these instruments for the purposes of flight, and those of the fore-arm (*radius* and *ulna*) are very long, and firmly united together; the ulna has a row of slight eminences for the attachment of the quills of the secondary feathers. The wrist, or *carpus*, is composed of but two bones, articulated to the radius and ulna, and which admit only of a *lateral* movement, by which the wings are folded close to the body. The bones of the hinder extremities consist of the thigh or *femur*;* the leg-bones, *tibia* † and *fibula*, the latter very small and anchylosed to the former; and of a *single shank-bone*, which supplies the place of the tarsal and metatarsal bones of other animals. This bone is articulated at its upper extremity to the tibia, and terminates at the lower end in distinct processes, which correspond in number with the toes; each process having a groove for the pulley-like tendon that moves the corresponding toe. This construction is peculiar to birds; for although in some quadrupeds, as the horse for example, the metatarsus consists of but one piece, the tarsus is composed of several bones.

The toes of birds present deviations equally recognisable; for the number of the articulations (or *phalangeal* pieces of bone) in each toe is different. Thus the thumb, or short toe, has *two* bones; the first toe on the inner side *three*; the the middle toe *four*; and the outer toe *five*. In general, three toes are directed forwards, and one backwards. In some species, the thumb or opposable toe is altogether wanting; in others, as in the swallow, it is directed forwards; in climbing birds, both the outer and the back toe are situated behind. The position of the hind toe, there-

* The acetabulum, or socket for the head of the thigh-bone, is always perforated. The femur has a surface for the articulation of the fibula; and by this character the femur of all birds may be distinguished. There is always a *patella*.

† The lower end of the tibia is very like that of the femur.

fore, affords an important indication of the habits of the bird (see *Wond.* p. 146, *Lign.* 23), and from a fragment of the lower extremity of the shank or tarso-metatarsal bone, with any trace of this articulation, we may determine whether the individual to which it belonged was a climber, wader, &c. In the toes of Crocodiles alone, the number of joints is the same as in birds; but in these reptiles, each toe is supported by a distinct metatarsal bone. The osteological peculiarities above enumerated may assist the collector in arriving at some general inferences as to the nature of any fossil remains of birds.

II. ORNITHOLITES, OR FOSSIL BIRDS.—The fossil remains of birds consist in general of their osseous skeletons, and of detached bones, and rarely of the feathers and eggs.

PLEISTOCENE EPOCH.—Bones of the DODO* (see *Wond.* p. 131), a bird which appears to have become extinct by human agency within the last two centuries, have been found, associated with the remains of a recent species of Tortoise, beneath a bed of lava in the Isle of France. And in some caverns in the island of Rodriguez, the bones of one or more large birds allied to the Dodo have also been discovered.

DINORNIS (*fearfully great bird*). *Pict. Atlas*, frontispiece, and p. 172.—Numerous bones of large extinct birds have been obtained in New Zealand by Mr. Rule, the Rev. W. Williams, Col. Wakefield, Mr. Walter Mantell, and others. These have been referred by Professor Owen to tridactylous struthious birds (one of which was one-third larger than the African ostrich), resembling the living *Apteryx* of New Zealand (*Wond.* p. 128; *Petrif.* p. 106) in the proportions of the tibia to the metatarsus, and also in the rudimental

* See Penny Cyclopædia, *Art.* DODO, and the beautiful work on the natural history of the Dodo and its Kindred, by the late lamented Mr. Strickland and Dr. Melville, 4to.

state of the wings. The bones are found in the recent alluvium, but probably in some cases at least they have been washed by the streams from older alluvial deposits.

An account of the history of the discovery of the gigantic Moa's bones in New Zealand (*Wond.* p. 129) is given in full in *Petrif.* p. 93, *et seq.*; and the scientific description of the various parts of the skeleton of the DINORNIS and PALAPTERYX, chiefly collected from Professor Owen's elaborate and finely illustrated memoirs in the Transactions of the Zoological Society, should be consulted, *Petrif.* p. 108, &c. Of *Dinornis* Professor Owen discriminates seven or eight species; of *Palapteryx*, three species; and indications of a species of a third associated genus, APTORNIS.

Fragments of egg-shell accompany these interesting relics of birds from New Zealand. From Madagascar also bird-bones and eggs have been obtained in a fossil state, that indicate the original bird (*Æpyornis*) to have been even of a greater size than the Dinornis.

ORNITHOLITES OF THE CAVERNS.—Many limestone districts abound in fissures and caves, which vary in extent from mere superficial hollows to deep excavations and caverns of considerable magnitude (*Wond.* p. 175, &c.) Beneath the stalagmitic or sparry floors of some of these caverns, the bones of extinct species of Cats, Bears, and Hyænas, occur in immense quantities; but the full consideration of these phenomena will be reserved for the next chapter. The skeletons and detached bones of several kinds of Birds are often found imbedded with these remains; and under circumstances which seem to indicate that they were brought into these caverns as prey by the carnivora, with whose relics they are now associated. Some examples show that the birds had fallen into the fissure; others, that their bones had been transported to their present situation by the action of water.

In the Cave of Kirkdale, in Yorkshire (*Wond.* p. 179),

Dr. Buckland found bones of the Raven, Lark, Pigeon, Duck, and others; and as almost all the specimens were the remains of wing-bones, it is considered probable that they are the relics of dead birds, which had been brought into the cave by the hyænas, whose den it is supposed to have been for a considerable period (*Reliquiæ Diluvianæ*, p. 34).

Similar remains have been discovered in the Kent's Hole cavern, and in that at Berry Head, Torbay; from the latter Professor Owen has obtained the wing-bones of a Falcon (*Brit. Fos. Mam. and Birds*, p. 558).

In France, the Lunel-Viel caverns have yielded a few bird-bones; and many such remains occur in the caves of Brazil, described by M. Lund.

The so-called "bone-breccia" of the coasts and islands of the Mediterranean (*Wond.* p. 185) contains frequent remains of birds: they have been especially noticed at Cette, Nice, Sardinia, and Gibraltar.

In the deposits especially referred to the northern drift or Boulder-clay period, fossil birds appear to be very rare, although the remains of vertebrate terrestrial animals are locally abundant. Dr. Buckland states that some bones, apparently of a species of goose, found at Lawford, with the remains of Hyæna, Elephant, Rhinoceros, &c., is the only instance he has met with of fossil birds in the drift of England (*Reliq. Diluv.* p. 27).

On the Continent, bird-bones have been found, at Quedlingbourg, Meissen, and in the Lahn Valley, in deposits said to be of this age.

Ornitholites of the Older Tertiary Deposits. (*Lign.* 246.)—The very rich pliocene deposits at Œningen (p. 559) have afforded a few fragments of birds' bones.

Three or four species of Ornitholites (Duck, Heron, Flamingo, &c.), and several examples of the eggs of birds,

have been discovered in the lacustrine strata of Auvergne. Birds' bones also occur in the freshwater limestone near Issoire, in the Puy de Dôme, associated with the remains of eocene mammalia. In Germany, bird-bones have been found in tertiary deposits at Wiesbaden, Wiesnau, and Mornbach. In the Siwalic Hills the remains of birds are associated with the fossil reptilia and mammalia, to which reference has already been made (p. 731).

From the quarries of gypseous limestone of Montmartre, near Paris, Baron Cuvier obtained many bones, and some connected portions of the skeletons of several birds related to the Pelican, Sea-lark, Curlew, Woodcock, Owl, Buzzard, and Quail.* In several of these examples there are the imprints and remains of the quills and feathers; in some the skeleton has perished, and a pellicle of dark-brown substance, with the configuration of the original, alone remains (see *Lign.* 246). These Ornitholites are associated with the bones of the Palæotheria, and other extinct mammalia of the eocene period. Two or three Ornitholites have been discovered at Montmartre, in which almost the entire skeleton is preserved. In one example, described by Cuvier, the remains of a bird are displayed in such a manner as to render it probable that the animal had fallen on its belly, and become partially impacted in the surface of the soft gypsum, which is now become solid stone; and that, previously to its being completely enveloped, the principal part of its head and the left leg were removed either by some voracious animal, or by the action of the water. In addition to the other parts of the skeleton, the under side of the bill is very distinctly impressed on the stone, and the left branch is entire; there are also the remains of the cellular basis of the skull; and both the wings are well preserved. Nine or ten species of fossil birds were identified by Cuvier from the Paris eocene strata.

* Ossemens Fossiles, tom. iii. p. 302, plates lxxii.—lxxv.

LITHORNIS VULTURINUS. *Geol. Trans.* 2d series, vol. vi. p. 206, pl. xxi. figs. 5 and 6.—Under the name of Lithornis (*petrified-bird*), Professor Owen has described the fossil

LIGN. 246. FOSSIL BIRD.
Eocene. Montmartre.
(Cuvier, *Oss. Foss.* vol. iii. p. 318, pl. lxxiii. fig. 2.)
The remains of this individual consist only of a thin brown pellicle, indicating the form and proportions of the head, body, and limbs.

remains of a bird, consisting of two most characteristic bones,—the sternum and sacrum,—and fragments of other bones, obtained from the London Clay of the Isle of Sheppey. These relics present a close agreement with the corresponding bones of the Vulture tribe, but indicate a smaller species of Vulture than any now known to exist.

In his " History of British Fossil Mammalia and Birds," 1846, Professor Owen has also described another *sacrum* from the Sheppey Clay, a *sternum* from Primrose Hill, and the *cranium* of a bird, probably of the *Halcyonidæ* family,

from the same eocene deposit at Sheppey. This has also yielded a portion of shank-bone, which, according to Mr. Bowerbank, indicates a bird of the size of a full-grown albatross. *Brit. Assoc.* 1851.

Some few specimens of cylindrical bones from the Chalk and the Wealden* have been previously referred to Birds, and described as remains of species of that family. These fossils, however, have lately been reexamined in comparison with more perfect bones of similar character; and, with the exception of a few, the structure of which decidedly has the characters belonging to bird's bone, the result of this investigation has assigned them to Pterodactyles.† The long thin cylindrical bones from the Stonesfield Oolite are probably all Pterodactylian also, as suggested by the late Mr. Miller.

III. ORNITHOIDICHNITES. (*Bird-like foot-prints.*) *Ligns.* 247, 248. *Bd.* pl. xxvi.*a*, xxvi.*b*.—The palæontological history

* One fragment of a bone, apparently of an *ulna*, retained a row of small eminences, probably the points of attachment for the quills of the secondary feathers of the wings. This specimen would appear to have a decided reference to ornithic structure, but it was transferred to the British Museum, and is not now to be seen.

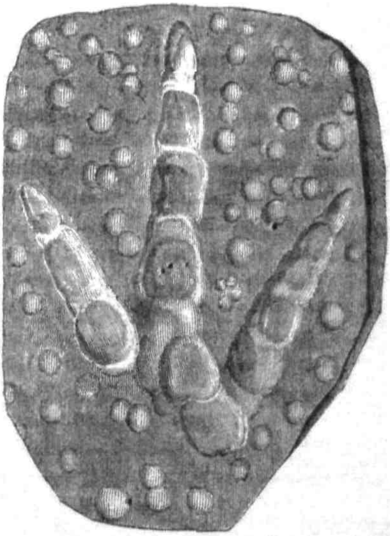
† See *Quart. Geol. Journ.* vol. ii. p. 96, &c.; and Owen's *Monograph on Chalk Reptiles*, 1851, p. 80, *et seq.* It is to be hoped that the eminent microscopists, Mr. Bowerbank and Professor Quekett, may be enabled before long to elucidate the intimate structure of pterodactylian bone; which, although of an essentially reptilian type, has characters of its own, offering some resemblances to bird-structure, that have not yet been fully described. Some specimens of bones from the Wealden (for instance, the specimen figured in *Geol. Trans.* 2d ser. vol. v. pl. xiii. fig. 6, and *Geol. Journ.* vol. iv. pl. i. fig. 9,) exhibit under the microscope an intimate structure resembling that seen in bird-bone, in contradistinction to that characteristic of reptilian bone. But until we are better acquainted with the microscopic structure of the osseous tissue of the Pterosaurians, and are in possession of more perfect specimens of bones, it cannot be satisfactorily determined to what extent the class of Birds existed in the country of the Iguanodon.

of the class of birds, as evidenced by the foregoing pages, is carried back but to a comparatively recent era in the earth's history: and indeed, in the present state of our knowledge, it may be said that all positive evidence of the former existence of this highly organized class of vertebrated animals is confined to the Tertiary and Wealden deposits. A most interesting discovery, however, by Dr. James Deane,* of Greenfield, U. S. seems to prove that numerous bird-like bipeds, and some of gigantic size, existed at the period when the Triassic or *New Red* strata were in the progress of formation; that period, as the reader will remember, in which the Labyrinthodonts and other extraordinary reptiles flourished. *Rep. Brit. Assoc.* 1841. p. 230, note.

In certain localities of the New Red sandstone in the valley of the Connecticut, numerous tridactyle markings had been occasionally observed on the surfaces of the slabs of stone when split asunder, in like manner as the ripple-marks appear on the successive layers of sandstone in Corncockle Muir, Tilgate Forest, &c. Some remarkable distinct impressions of this kind at Turner's Falls (Massachusetts) happening to attract the attention of Dr. Deane, that sagacious observer was struck with their resemblance to the foot-marks left on the mud-banks of the adjacent river by the aquatic birds which had recently frequented the spot. The conviction that the imprints on the stone were referable to a similar origin with those on the mud was so strongly impressed on his mind, that he immediately collected a series of specimens, and communicated his discovery and opinion to Professor E. Hitchcock, who followed up the inquiry with a zeal and success that have led to the most interesting results. No reasonable doubt now exists that the imprints in question have been produced by the

* See "Illustrations of Fossil Foot-prints of the Valley of the Connecticut," 1849, 4to. with nine plates.

The above will suffice to give the reader a general idea of the nature of these extraordinary impressions. A few shapeless fragments of bones are the only vestiges of the skeletons of any animals, with the exception of fishes, that have been found in the strata which have furnished the slabs of Ornithoidichnites. Some Coprolites also have been discovered.



LIGN. 248. BIRD-LIKE FOOTPRINT, AND IMPRESSIONS OF RAIN-DROPS, ON SANDSTONE (*nat.*). *New Red Formation; Massachusetts.*
[Amer. Journ. of Science, (1843,) vol. xlvi. p. 73.]

The enormous size of some of the foot-marks is calculated to excite great surprise. I have in my possession (through the kindness of Dr. Deane) imprints that prove the size of the foot to have been fifteen inches in length, and ten inches in width, exclusive of the hind claw, which is present

in a block of limestone; but, when exposed by breaking the stone, a portion of the shaft may alone remain attached, and both extremities be shattered to pieces by the concussion of the blow; yet, if the impression remains, the entire form of the original may be determined.

The *foot-prints*, not only of birds, but of reptiles and other animals, should be diligently sought for on the surfaces of laminated strata of sand and clay, and especially where the presence of ripple-marks, and the impressions of rain-drops, indicate that the beds were deposited in shallow water. The forest-marble flags at Castle Comb, north of Bath, the Stonesfield slates, and the sandstones around Horsham (in Sussex), and particularly at Stammerham (see *Geol. S. E.* p. 213), are often rippled; and it is therefore probable that the foot-prints of some of the Oolitic and Wealden quadrupeds and bipeds, if such existed, will sooner or later be discovered.

CHAPTER XIX.

FOSSIL MAMMALIA.

THE remains of MAMMALIA discovered in a fossil state include an immense number of species, and furnish examples of almost every living genus, and of numerous genera, and even orders, of which no existing species are known. Yet amidst the vast accumulations of the skeletons of the higher orders of vertebrata contained in the tertiary deposits, and in the superficial drift, belonging to species which have successively appeared on the surface of our planet, flourished for indefinite periods of time, and then become annihilated, no vestiges of MAN, or of his works, have been detected. Human skeletons, naturally imbedded, have hitherto only been observed in the silt of modern alluvial plains,* in peat-bogs (*Wond.* p. 64), and in conglomerates of recent date, such as are in the progress of formation on the sea-shores, particularly where the water is loaded with the detritus of shells and corals, and the waves transport the calcareous matter along the margins of creeks and bays, or deposit it in the shallows along the coast (see *Wond.* p. 87, and *Petrif.* p. 483).

The geological distribution of fossil mammalia,†—the occurrence of the entire carcases of extinct species of Elephant

* There seems, however, reason to believe that the human skulls and bones found with elephantine and other remains in the Alps of Swabia, are of contemporaneous origin with these extinct mammals. (See *Literary Gazette*, 1853, p. 1027.)

† For a notice of the distribution of mammalian remains in the Upper Tertiaries of Europe, see Phillips's *Geology*, 1853, vol. i. p. 45, &c.

and Rhinoceros in blocks of ice (*Wond.* p. 151),—of recent species in the superficial alluvial clay and silt,—of recent and extinct forms in the Drift or Pleistocene deposits (*Wond.* p. 147),—of the gradual preponderance of unknown species and genera, in proportion as we carry back our retrospect to the most ancient Tertiary strata (*Wond.* p. 254), —the sudden disappearance of all vestiges of the entire Class of Mammalia, with the last bed of the Eocene deposits,—with the exception of a few minute jaws in one set of beds of the Oolite in England (*Wond.* p. 510), and of a few teeth in the Trias (?) of Germany,* the sole records of the existence of any of the highest types of animal organization throughout the vast periods of the secondary formations—are so fully treated of in the *Wonders of Geology*, that I need not dwell upon the subject in the present volumes. Neither is it desirable to enter at large upon this department of Palæontology, for it were vain to attempt the elucidation of the anatomical characters of but one extinct species of Mammalia, without giving details of structure, that could only be successfully demonstrated in a work expressly devoted to the subject. Referring, therefore, to Cuvier's *Ossemens Fossiles*, and to Professor Owen's "*History of the British Fossil Mammalia*," 8vo. 1846, I must limit my remarks on the Fossil Mammalia to a brief summary of modern discoveries, with suggestions for the identification and collection of some of the most interesting or prevalent remains.

The fossil remains of Mammalia will be considered under the following heads:—

I. CETACEA, or animals of the *Whale tribe*.

II. RUMINANTIA; including the *Camel, Giraffe, Deer, Sheep, Ox*, &c.

* For an account of these teeth of small insectivorous mammals from the "bone-bed" of Würtemberg, which has an analogous position at the top of the Trias with the "bone-bed" of Axmouth and Austcliff, see *Ly.* p. xiv. figs. 529—531.

III. PACHYDERMATA; comprising the *Proboscideans*, as the *Elephant*, and the ordinary *Pachyderms*, as the *Rhinoceros*, *Horse*, *Swine*, &c.

IV. EDENTATA; animals without teeth, or with only molars, as the *Ant-eater*, *Sloth*, *Megatherium*, *Mylodon*, &c.

V. RODENTIA, or GNAWERS; as the *Hare*, *Beaver*, *Rat*, &c.

VI. MARSUPIALIA; animals with an abdominal pouch, as the *Kangaroo*, *Opossum*, &c.

VII. CARNIVORA; including the *Bats*, *Moles*, and the carnivorous tribes in general.

VIII. QUADRUMANA; *Apes* and *Monkeys*.

IX. BIMANA; or *Man*.

I. FOSSIL CETACEA.*—The *Cetaceans*, although popularly termed fishes, are as perfect air-breathing vertebrated animals, as the terrestrial mammalia, and, like them, give suck to their young. Instead of fore-feet or arms, they have a pair of fins or paddles, but are destitute of hinder extremities, the place of the latter organs being supplied by a powerful cartilaginous horizontal fin, appended to the tail. The Cetaceans, therefore, differ in this respect from the fossil marine reptiles, the Ichthyosaurus and Plesiosaurus (see p. 662), which have two pairs of paddles. This order, as is well known, comprises the most colossal forms of animal existence,—the Whales. Some are herbivorous, others carnivorous; many have powerful teeth; others are edentulous, the jaw being furnished with a series of elongate plates of the substance familiarly known by the name of *whale-bone*.

The fossil remains of Cetaceans have, for the most part, been observed in alluvial silt and beds of drift, in valleys still traversed by rivers; but many examples have been discovered in elevated sea-beaches, proving that, although,

* *Cetacea*: an order of aquatic mammalia, comprising the Whales, Narwhals, Porpoises, Dolphins, and Dugongs.

geologically speaking, these beds are of modern origin, yet great changes in the relative level of the land and sea must have taken place since these remains were imbedded. Thus, on the banks of the river Forth, near Alloa, in Scotland, the skeleton of a Whale (*Balænoptera*), seventy-two feet long, was discovered imbedded in clay, twenty feet above the highest tide.* Cuvier mentions the discovery of bones of a *Lamantin* at Angers; of a Dolphin, and Rorqual, in Lombardy; and of a Grampus, in the pliocene of the Sub-Apennines.†

OTOLITHES OF CETACEANS.—Petro-tympanic bones of several large whales have been found in great numbers in the red Crag of Felixstow; among them is one of the genus Physeter, or Sperm-Whale.‡

BRIGHTON FOSSIL WHALE.—An interesting discovery of the anterior half of one side of the lower jaw of a Whale, undoubtedly coeval with the extinct Mammoth (*Elephas primigenius*), was made in 1828 in the Cliff, east of Kemp Town, Brighton, under the following circumstances. On the face of the Cliff, in the ancient shingle which lies immediately upon the chalk and is surmounted by beds of calcareous rubble, containing bones and teeth of Elephants, to the height of one hundred and twenty feet, some fishermen had observed a huge bone, that had been laid bare by an unusually high tide and now projected two or three feet beyond the face of the Cliff. Unable to remove it, they broke off the extremity, a fragment of which was sent to me. Upon repairing to the spot a few days afterwards, I found that the fishermen had renewed their attack, and demolished a considerable portion of the bone in ineffectual attempts to dislodge it from its bed; and had desisted only from the

* Dr. Fleming's *British Animals*, p. 39.

† For notices and descriptions of Cetacean remains found in England, see Owen's *Brit. Foss. Mammalia*, p. 516, *et seq.*

‡ Proc. Geol. Soc. for 1845, p. 41; and Brit. Foss. Mam. p. 526, &c.

apprehension of being buried beneath the overhanging cliff, which is composed of loosely aggregated materials. Unfortunately, the bone extended directly into the cliff, and it required several hours of labour, not unattended with danger, before an excavation was made sufficiently large to expose the entire specimen. It proved to be the anterior *nine feet* of the left branch of the lower jaw of a whale-bone Whale (*Balæna mysticetus*). It was of a light fawn colour externally, but the internal coarse osseous structure was delicately white; it was extremely brittle, and, upon attempting to move it, broke into a thousand pieces. Time would not permit of the application of a coating of plaster of Paris, for ere we had completed our task the tide was rapidly approaching, or this interesting relic might have been extracted entire. This portion of lower jaw, before it was mutilated by the fishermen, was twelve feet long, and thirty-six inches in circumference at the largest extremity. It must have belonged to a Whale from sixty to seventy feet in length.*

In the fluviatile silt of the valley of the Ouse, near Lewes (*Wond.* p. 63), the skull of a Porpoise and a portion of the cranium, with the socket of the long straight tooth, of a Narwhal (*Monodon monoceros*), were found twelve feet beneath the surface of the soil.

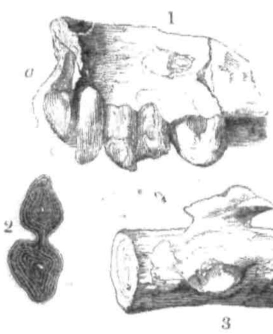
The bones of an herbivorous Cetacean, the *Manatus*, a genus now peculiar to the torrid zone, have been found in the eocene strata in various parts of France, associated with those of the Palæotheria and other extinct mammalia of the Paris basin.

Zeuglodon cetoides. *Lign.* 249.†—The remains of a

* The fragments of this jaw that were preserved are now exhibited in the British Museum, in Room V.

† Owen, *Geol. Trans.* 2d ser. vol. vi. p. 69, &c., plates vii. viii. ix.; Harlan's *Medical and Physical Researches*, p. 337, &c.; Gibbes, *Journ. Acad. Nat. Sc. Philadelphia*, 2d ser. 1847, vol. i. pp. 5 and 16; Bulkley, *Silliman's Journal*, vol. xliv. p. 409; Carus, *Nova Acta Cur. Nat.* vol. xxii. pt. ii. 1848.

very remarkable Cetacean, of an extinct genus, were first made known by Dr. Harlan, of Philadelphia, who obtained a considerable portion of the jaws with teeth, vertebræ, and other bones of an animal of enormous size, from Alabama and Arkansas, United States. These relics were discovered in tertiary (*eocene*) limestone, associated with a marine shelly conglomerate, from a cliff near the bed of the river Owachita. When first observed, the bones extended along



LIGN. 249. ZEUGLODON CETOIDES.

PORTION OF THE JAW, WITH TEETH, AND A VERTEBRA.

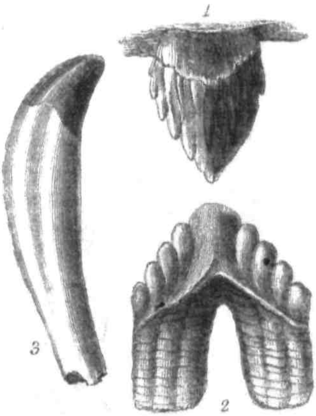
Eocene. Alabama, United States.

Fig. 1.—Portion of the Upper Jaw, with three teeth: $\frac{1}{8}$ *nat.*
a. The exposed fang of a tooth.
2.—Transverse section of the base of the crown of a tooth, showing the deep constriction in the middle: $\frac{3}{4}$ *nat.*
3.—A caudal vertebra: $\frac{1}{12}$ *nat.*

the face of the rock, with intervals between them, to the extent of one hundred feet, and the animal to which they belonged must have exceeded seventy feet in length. Dr. Harlan ascribed these bones to an unknown reptile, which he called Basilosaurus (*king of the lizards*); but a more correct investigation, by Professor Owen, proved their

cetacean character, and the peculiar form of the worn molar teeth suggested the name of *Zeuglodon* (*yoke-tooth*).

The teeth (*Lign.* 250) are of two kinds, some having but one fang, and others two, implanted in separate sockets and



LIGN. 250. TEETH OF ZEUGLODON: ½ *nat.*

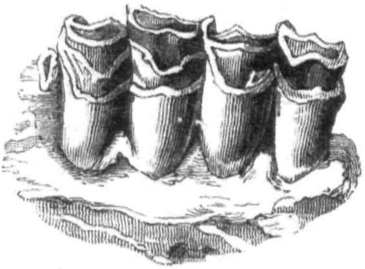
Eocene. France and N. America.

Fig. 1.—Upper tooth of Z. SQUALODON; from near Bordeaux.
2.—Molar tooth of Z. CETOIDES; from Alabama, United States.
3.—Canine tooth of Z. CETOIDES.

placed obliquely in the jaw; they are of a compressed, conical form, with an obtuse apex, the crown being deeply conjugate, or contracted in the middle, as shown in the transverse section, *Lign.* 249, *fig.* 2. They are devoid of enamel, but the dentine is coated with cement, and their structure is decidedly mammalian; and a microscopical examination, Professor Owen states, incontestably proves their cetacean character. The longitudinal diameter of the middle tooth is three inches.

The vertebræ resemble those of the large cetacean known by the name of *Hyperoodon;* a caudal vertebra is figured *Lign.* 249, *fig.* 3. The original animal was related to the Dugong and Cacholot, and appears to have held an intermediate place between the latter and the herbivorous species.

II. Fossil Ruminants. (*Owen's Brit. Foss. Mam.* p. 444, *et seq.*)—The fossil bones of animals of this order are very numerous in the alluvial deposits, in caves, and in pleistocene deposits, in almost every part of the world. They are



Lign. 251. Teeth of a Ruminant. *Pleistocene. Gibraltar.*
Imbedded in a mass of the "osseous breccia."

generally associated with the remains of the next group. The skulls of Oxen, and horns and bones of the Bison and Auroch, have been found in North Cliff, Yorkshire, at Walton in Essex, and other parts of England. The fossil oxen appear to have been one-third larger than the recent species; and the horns are relatively more massive than in the domestic race; some of the horns measure four feet across, at the widest expansion. In the immense accumulations of large mammalia in the tertiary beds of the Sub-Himalayan or Siwalik range, numerous remains of oxen

occur. The teeth of one species are often found in the Elephant bed at Brighton.

Of the Deer family the relics of several kinds have been discovered in Drift and Caverns. The cave of Kirkdale alone contained the remains of three species.* The bones of a species that cannot be distinguished from the common Red Deer are found in the modern shell-marls of Scotland, associated with the remains of oxen, horse, boar, dog, wolf, and beaver. The bones and antlers of the Reindeer have been found at Brentford and other places (*Brit. Foss. Mam.* p. 479; and *Rep. Brit. Assoc.* 1851. Sect. p. 69). The ossiferous caverns, which contain bones of Carnivora, also yield those of Deer; as the caves of Kirkdale and Banwell, &c. in England, and the celebrated caverns of Muggendorf, on the Continent. A species of Musk-deer has been found at Epplesheim; and bones of deer are associated with those of the Dinotherium, in Rhenish Hesse, in late Tertiary deposits. The teeth and a lower jaw, with other bones, of a species of deer, were obtained from the Brighton Elephant bed (*Wond.* p. 114).

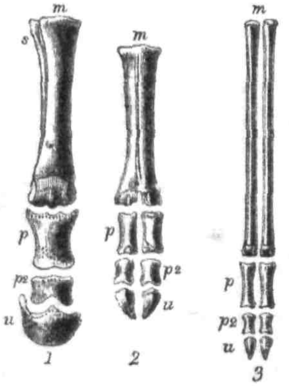
The most celebrated fossil animal of this family is the Gigantic Stag or Deer of Ireland (see *Petrif.* p. 455; *Wond.* p. 132), whose bones and antlers are found in immense quantities in superficial marl, in Ireland, in the Isle of Man, and occasionally in England. (*Geol. Journ.* vol. iv. p. 42.) A skeleton that was found, almost entire, in marl abounding in fresh-water shells, at the depth of twenty feet, is six feet high, nine feet long, and nine and a half feet in height, to the top of the right horn. Some antlers are so large, that the interspace from one point to the other exceeds twelve feet.†

* The Rev. Dr. Buckland's *Reliquiæ Diluvianæ;* or, Observations on the Organic Remains found in Caves, Fissures, and Gravel; 1 vol. 4to. 1823, pl. viii. and ix.

† See *Pict. Atlas.* pl. lxxi.; a good figure of the skeleton of the fossil Irish Deer is given in the Penny Cyclopædia, vol. viii. p. 364;

The GIRAFFE, the tallest of known quadrupeds, and now restricted to the deserts of Africa, was once a native of Europe and Asia, for fossil bones of a species of this remarkable ruminant have been found at Issoudun, in France, and in the Siwalik mountains, with several varieties of Elk and Deer.

Of the CAMEL, the only ruminant with incisor teeth in the upper jaw, a gigantic species has been discovered by Dr. Falconer and Captain Cautley, in the Siwalik range.



LIGN. 252. BONES OF THE FEET OF HORSE, DEER, AND ANOPLOTHERIUM.

Fig. 1.—Fore-foot of the Horse.
2. ——— Deer.
3. ——— ANOPLOTHERIUM GRACILE.

m, m. Metacarpal bones ("canon-bone" in the Horse.)
s, in fig. 1, the "splint-bone," or rudimentary metacarpal.
p, p. First or proximal phalangeal-bones ("pastern" in the Horse).
p2, p2. Second phalangeals ("coronet" or "crown-bone" in the Horse).
u, u. Unguals, or bones of the hoof ("coffin-bone" in the Horse).

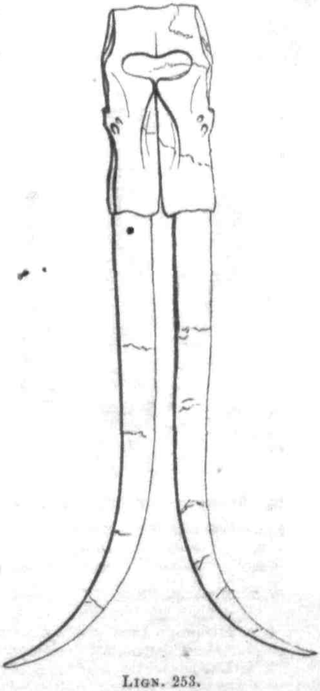
In this category we must notice another most interesting discovery of the indefatigable and eminent naturalists above

for a detailed account of this gigantic animal, see Owen's *Foss. Brit. Mammalia*, p. 444, and *Charlesworth's Journal*, p. 87.

mentioned, namely, the *Sivatherium* (see *Wond.* p. 163), an extinct animal, which forms, as it were, a link between the ruminants and the large pachydermata. The skull has four persistent horns, and was furnished with a nasal proboscis. The living creature must have resembled an immense Antelope or Gnu, with a short thick head and an elevated cranium, crested with two pairs of horns. A splendid specimen of the skull of the *Sivatherium* has been placed in the palæontological collection of the British Museum by Dr. Falconer (*Petrif.* p. 456, *Lign.* 98).

III. PACHYDERMATA.*—The fossil remains of this order of mammalia are most abundant, and belong to numerous species, comprising many extinct genera of a highly interesting character. See Pictet's *Paléontologie*, new edit. 1853, vol. i. p. 127, *et seq.*

FOSSIL ELEPHANTS AND MASTODONS. *Lign.* 253, 254, 258—260. *Owen's Hist. Brit. Foss. Mam.* p. 217, &c.; *Wond.* pp. 147, 157.—The bones,

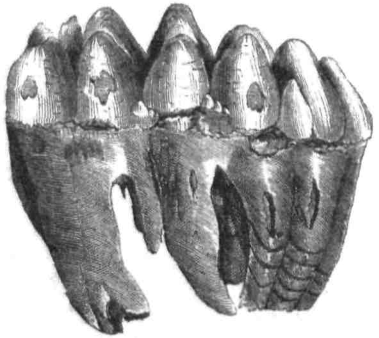


LIGN. 253.
ELEPHAS GANESA.
Front view of the Cranium and Tusks.
(*The original is 14 feet long.*)

* See Owen on the Classification of the Pachydermata, *Quart. Geol. Journ.* vol. iv. p. 127, &c.

teeth, and tusks of Elephants, equal in magnitude to, and distinct from the existing African and Asiatic species, are scattered throughout the superficial alluvial and pleistocene accumulations of Europe.

The fossil bones and teeth (*Pict. Atlas*, pl. lxxi. lxxiv.) of these gigantic animals are so abundant, that examples may be found in all the provincial, and in most private collections; and the British Museum possesses an unrivalled series of specimens of both groups of these colossal herbivorous mammalia, namely, the Elephants properly so called and the Mastodons (*Petrif.* pp. 463, 471). It contains an



LIGN. 254. MASTODON GIGANTEUS.
Unworn Molar Tooth: ⅓ *nat. size.*
Upper Tertiary. Banks of the Hudson, N. America.

invaluable series of specimens from the Siwalik hills, presented by Capt. Cautley and Dr. Falconer (*Petrif.* p. 469); amongst which are remains in which the dental organs present every modification of structure, from that of the mastoid tubercles of the tooth of the Mastodon, to the vertical laminæ of cement, enamel, and dentine of the Elephant. The Museum also possesses the entire skeleton of the Mastodon (*Petrif. Lign.* 107) formerly exhibited by M. Koch,

as well as the fine suite of jaws and teeth obtained by the same indefatigable collector. This collection demonstrates that all the bones and teeth, apparently of several species, and, as some have supposed, of distinct genera, belong but to the one grand Mastodon—the *M. giganteus* of Cuvier; it also clearly proves that the young mastodon had a pair of tusks placed horizontally in the lower jaw; and that but one of these tusks became developed in the adult, and that only in the male.*

It is therefore unnecessary to enlarge upon this subject, for an inspection of a few specimens will afford the student a clearer insight into the structure of the skeletons and teeth of these animals than any description. The form of the teeth, and the disposition of the dental elements, are illustrated in *Wond.* p. 143, and *Ly.* p. 159.

DINOTHERIUM. *Petrif.* p. 474; *Wond.* p. 173; *Bd.* i. p. 135, pl. ii.—At Epplesheim, forty miles north-east of Darmstadt, in beds of sand and marl of the median Tertiary formations, the jaws, teeth, skull, and other remains of the Dinothere, one of the most gigantic of terrestrial mammalians, have been discovered; they are preserved in the museum at Darmstadt. The length of the largest species is estimated at eighteen feet. The teeth had previously been found in France, Bavaria, and Austria; and, from their close analogy to those of the Tapir, were described by Cuvier as belonging to an extinct colossal animal of that genus. But subsequent discoveries have shown that the *Dinotherium* was probably a proboscideal animal, and had two large curved tusks directed downwards in the anterior extremity of the lower jaw.†

* This remarkable circumstance, in the infancy of palæontological science, gave rise to a very venial error; it was made to constitute the character of a new genus, to which the name *Tetracaulodon* was applied.

† There are some fine specimens, and good models of the Darmstadt specimens, in the British Museum (*Petrif.* p. 474).

LIGN. 255.

ANOPLOTHERIUM COMMUNE.

Eocene Tertiary. Montmartre.

Restored outline of the animal; after Cuvier.

(The original was about the size of an Ass.)

CUVIERIAN PACHYDERMS. *Lign.* 255, 256. *Owen's Brit. Foss. Mam.* p. 299, &c.; *Wond.* p. 254; *Bd.* i. p. 81; *Petrif.* p. 475.—A large proportion of the numerous bones and teeth which are found in the Tertiary gypseous deposits at Montmartre, near Paris, are referable to the several extinct genera of Pachydermata, which the genius of Cuvier first made known. The *Palæotheria* and *Anoplotheria* must be familiar to the intelligent reader, for the restored outlines of several species are appended to almost every work that treats of the ancient inhabitants of our globe. The details of their anatomical characters are given at length in *Oss. Foss.* tom. iii., illustrated with numerous plates.

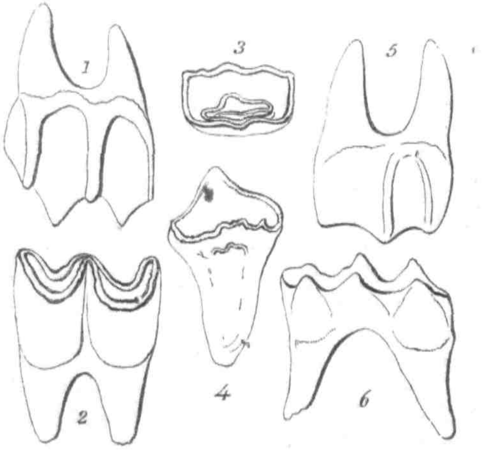
The PALÆOTHERIA (*Brit. Foss. Mam.* p. 316, *et seq.*) resembled the Tapirs in their head and short proboscis, while their molar teeth approached those of the Rhinoceros, and their feet were divided into three toes, instead of four, as in the Tapirs. Upwards of eleven species have been discovered, varying from the size of the Rhinoceros to that of the Hog. Their remains are extensively diffused in the Upper Eocene strata in various parts of France; and have been found in the Isle of Wight.

The LOPHIODON (*crested-tooth*), a genus distinguished from the former by the characters of the teeth, which more nearly resemble those of the Tapirs, comprehends twelve species, all found in the fresh-water Tertiary marls of France. A canine tooth of a species of *Lophiodon* was found in the London Clay, in sinking a well on Sydenham Common, near the railway.*

The ANOPLOTHERIA have two characters not observed in any other animal, namely feet with two toes (see *Lign.* 252), the metacarpal and metatarsal bones of which do not unite into a single piece, as is the case in the ruminants; and teeth placed in a continued series without any interval

* See Mr. Douglas Allport's interesting *History of Camberwell*, p. 17, and Owen's *Brit. Foss. Mam.* p. 306.

between them (*Petrif. Lign.* 111); man alone has the teeth arranged in the same manner. I subjoin figures of molar teeth of *Palæotherium* and *Anoplotherium* (*Lign.* 256).



LIGN. 256. TEETH OF PALÆOTHERIUM AND ANOPLOTHERIUM.

Upper Eocene. Isle of Wight and Montmartre.

Fig. 1.—Upper molar tooth (external surface) of PALÆOTHERIUM MAGNUM. *Binstead.*
2.—Lower molar of PALÆOTHERIUM MAGNUM.
3.—Grinding surface of first upper molar of ANOPLOTHERIUM SECUNDARIUM. *Binstead.*
4.—Inner side view of right upper canine of ANOPLOTHERIUM COMMUNE.
5.—Upper molar of ANOPLOTHERIUM COMMUNE. *Montmartre.*
6.—Lower molar of the same animal.

There are also sub-genera, as for example, *Xiphodon* and *Dichobune*, characterized by peculiarities of dental and osteological structure; and *Anthracotherium* (so named from two species having been found in a bed of Anthracite or Lignite, near Savone), a genus intermediate between the Palæotheria and Hogs. The skeletons of these remarkable

animals are imbedded with the remains of carnivora, marsupialia, bats, birds, crocodiles, tortoises, and fishes.

In England, no remains of the extinct Pachydermata of the Paris Tertiary strata were discovered until a few years since, and they are still exceedingly rare. There have been found in the fresh-water limestone at Binstead, near Ryde, and at Seafield, Isle of Wight, (see *Geol. I. Wight*, 1854, Prefat. Note,) teeth and portions of the jaws of two species of Anoplotherium, four of Palæotherium, and one of *Chæropotamus*, an animal allied to the Hog Tribe (*Geol. Trans.* 2d ser. vol. vi. pl. iv.; and *Brit. Foss. Mam.* p. 413, &c.).

The *Hyopotamus* (*Lign.* 257) is a genus of Anthracotherioid pachyderms, two species of which have been determined by Prof. Owen (*Quart. Geol. Journ.* vol. iv. p. 103, &c.), from specimens of teeth found in the upper eocene of the north-west coast of the Isle of Wight, by the Marchioness of Hastings.

The *Palæotherium*, *Dichobune*, *Dichodon*, *Paloplotherium*, and others occur in the upper eocene fresh-water deposits of Hordwell Cliff (see *Charlesworth's Journal*, No. 1, p. 5, and pl. ii.; *Quart. Geol. Journ.* vol. iv. p. 17, and pl. iii.; and *Rep. Brit. Assoc.* 1851, *sect.* p. 67).

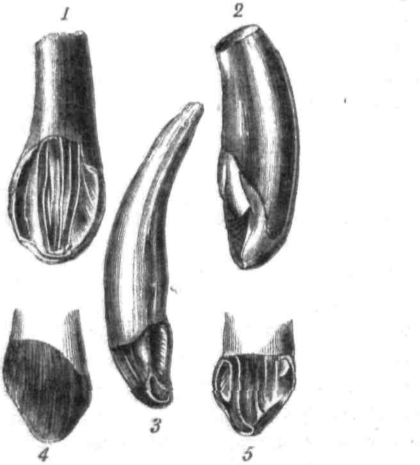
Two species of a new genus, intermediate between the Hog and the Hyrax, named by Professor Owen *Hyracotherium*, have been discovered in the eocene sands at Kyson, in Suffolk, and in the London Clay of the cliffs at Studd Hill, about a mile to the west of Herne Bay.* The latter specimen consists of a mutilated skull, about the size of that of a Hare, with the molar teeth perfect.

The *Paloplotherium*, an allied genus, from Hordwell Cliff, is described in *Geol. Journ.* vol. iv. p. 103.

The other large fossil Pachyderms, belonging to the two existing genera of Rhinoceros and Hippopotamus, are found

* Geol. Trans. 2d ser. vol. vi. pl. xxi. p. 203; and *Brit. Foss. Mam.* p. 419, &c.

very extensively distributed in alluvial debris, in the ossiferous breccia of caverns, and in other pleistocene deposits; and their remains are frequently dug up in the superficial marls, clays, gravel, and sand of England. As the teeth of



LIGN. 257. HYOPOTAMUS.

Incisor Teeth: *nat. size.* *Upper Eocene.* *Isle of Wight.*

Fig. 1.—Inner surface of an incisor of *Hyopotamus*.
3.—Lateral view of an upper incisor of *Hyopotamus*.
4.—Outer aspect of the crown of the same tooth.
5.—Inner aspect of ditto.
2.—Lateral view of the upper incisor of recent Hog (*Sus scrofa*).

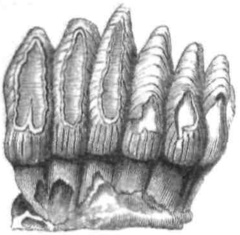
(These figures are from plate vii. *Quart. Geol. Journ.* vol. iv.; but the drawings have been accidentally reversed.)

these animals will occasionally be met with by the collector, a brief explanation of their form and structure may be useful.

TEETH OF MAMMALIA.*—The organization of the teeth in the herbivorous mammalia essentially consists in the adaptation of the three elements of dental structure to the peculiar conditions required by the habits and economy of the different species. Thus, in the Elephant (*Lign.* 259, 260), Horse (*Lign.* 263), &c., the dentine, cement, and enamel are disposed in vertical plates more or less inflected, the enamel and cement penetrating the body of the tooth, and embracing corresponding processes of dentine; an arrangement by which a grinding surface, composed of three substances of unequal densities, is produced and maintained in every state of detrition (*Owen*). But these teeth do not possess the symmetrical and complicated structure observable in those of many of the reptiles and fishes we have previously investigated. In the carnivorous mammalia, the enamel constitutes an external shell or case, investing the body of dentine and presenting sharp cusps or trenchant ridges, adapted for the laceration of flesh, as in the Tiger, or modified so as to form instruments for snapping and crushing bones, as in the teeth of the Hyæna. In the Mastodon, the crown of the tooth, when first emerged from the gum, presents a series of strong conical eminences (*Lign.* 254), that become worn down by use, at first into disks (*Ly.* p. 157), which, by further detrition, coalesce. The tooth of the Elephant (*Lign.* 259 and 260), on the contrary, consists of vertical plates of dentine, with an immediate investment of enamel, over which there is an external layer of cement that binds together the entire series of plates, often amounting to twenty or more; the horizontal surface produced by the detrition of such a structure, gives rise to the well-known

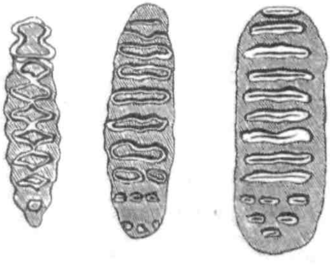
* For the minute structure of the dental organs, the modes of dentition prevalent in the mammalia, and the homologies of the teeth, we must refer to Prof Owen's often-quoted works, the matchless *Odontography*, and the lucid and compendious Article on TEETH, in the *Cyclopædia of Anatomy and Physiology*.

grinding surface of the molars of the elephant (*Lign.* 259, 260; *Wond.* pp. 143 and 160; *Ly.* p. 159; *Owen's Brit.*



Lign. 258.
Tooth of Mastodon elephantoides: $\frac{1}{6}$ *nat. size.*
Upper Tertiary. Ava, Burmah.

Lign. 259.
Tooth of Elephas primigenius: $\frac{1}{6}$ *nat. size.*
Upper Tertiary. Big-bone-lick. N. America.



1 2 3

Lign. 260. Teeth of Elephants: $\frac{1}{6}$ *nat. size.*

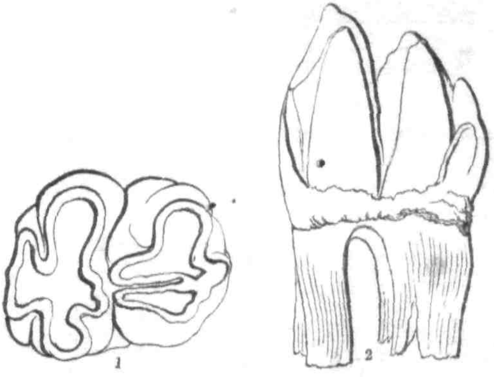
The grinding surfaces of the teeth exhibit the arrangement of the bands of enamel, which have an analogous, but somewhat different distribution in the teeth of the different species of Elephant.

Fig. 1.—The worn surface of a molar tooth of the African Elephant.
2.—That of the Fossil Elephant or Mammoth (*Elephas primigenius.*)
3.—That of the Asiatic Elephant.

Foss. Mam. figs. 88—90, &c.). Detached plates of the teeth of Elephants, particularly of those which belong to the back

part of the posterior grinder, and have not come into use, are puzzling to the inexperienced collector of fossil remains; and the first indication I obtained of the existence of the remains of fossil Elephants in Brighton Cliffs (*Wond.* p. 150), was from a mass of this kind, dug up in sinking a well in Dorset Gardens, and sent to me as a "petrified cauliflower."

I subjoin (*Lign.* 261, *fig.* 1) a figure of the crown of a fossil molar tooth of a Hippopotamus, from Kent's Cavern,



LIGN. 261. FOSSIL MOLAR TEETH OF HIPPOPOTAMUS: ⅔ *nat.*

Pleistocene.

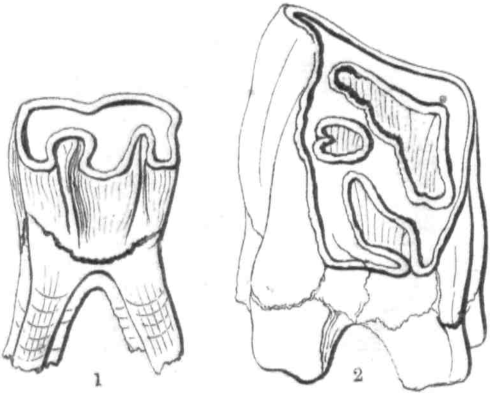
Fig. 1.—Grinding surface of a molar tooth, with the cusps partially worn away. *Kent's Cavern, Devonshire.*

2.—Perfect molar tooth, seen laterally. *Hertfordshire.*

Devonshire; in this specimen the summits of the cusps are worn down by use; and another, *fig.* 2, representing a perfect molar, with the conical cusps of the crown entire, found in Hertfordshire by W. D. Saull, Esq. The form of the worn surfaces of the molars of the Rhinoceros,* is shown

* See Translation of a Memoir by Giebel on the fossil remains of Rhinoceros in the *Quart. Journ. Geol. Soc.* vol. viii. part ii. p. 9, &c.

in two different stages in the fossil teeth represented *Lign.* 262. Sir C. Lyell has given figures of the teeth of the Horse, Ox, Deer, &c. (*Ly.* p. 160); but teeth of the recent species are so readily obtained, and so much more instructive, that I would recommend the student to procure teeth



LIGN. 262. FOSSIL MOLAR TOOTH OF RHINOCEROS: ⅔ *nat.*

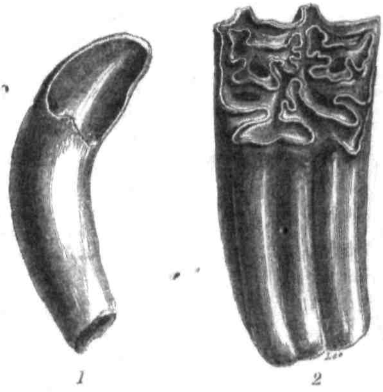
Pleistocene.

Fig. 1.—A molar tooth much worn down by use; with the fangs nearly perfect. *In gravel; Petteridge Common, Surrey.*
2.—Large molar, very much worn by use; the fangs broken off. *Kent's Cavern, Devonshire.*

of the domestic herbivorous, carnivorous, and rodent animals, and preserve them in his cabinet as objects for comparison with the fossil mammalian teeth he may discover (see *Pict. Atlas*, pl. lxxii.).

FOSSIL HORSE. *Lign.* 263; and *Owen's Brit. Foss. Mam.* p. 383, *et seq.*—The bones and teeth of one or more species of this widely distributed genus are found in the alluvium, in osseous breccia, and in caverns in numerous localities in Europe, Asia, and America. The teeth and bones of the

horse are often met with in the Elephant bed in Brighton cliffs; they are referable to a small species, about the size of a Shetland pony. The blue alluvial clay or silt of our existing river-valleys contains abundance of the remains of a horse not distinguishable from the recent.



LIGN. 263. TEETH OF FOSSIL HORSE: *nat. size.*

Pleistocene. England.

Fig. 1.—Right lower canine tooth of young EQUUS PLICIDENS; from the Cave at Oreston (Owen's *Foss. Mam.* p. 394).

2.—Upper molar of a fossil Horse; from the *Elephant-bed* of Brighton Cliffs.

In the Siwalik hills, collocated with the gigantic pachydermata, ruminants, and carnivora, the remains of two or more species of Horse have been discovered. One form (*Hippotherium*) is remarkably distinguished from any previously known by the extreme length and slenderness of its legs, in which respect it must have closely resembled the Antelope; it did not surpass in size the common Deer.

IV. FOSSIL EDENTATA. *Petrif.* p. 476.—The remains of extinct colossal mammalia, related to the existing diminutive SLOTHS in the essential characters of their organization, but modified to suit the peculiar conditions in which they were placed and the enormous increase in bulk of their colossal frames, are strewn all over the vast area of those alluvial plains of South America, called the PAMPAS (*Wond.* p. 164). The deposits of these regions * consist of—1. Beds of clay, sand, and limestone, containing marine shells and teeth of sharks; these are the lowermost strata. 2. Indurated marl. 3. Red clayey earth with calcareous concretions, in which the bones of colossal terrestrial mammalia are abundant. This vertical section demonstrates, that an extensive bay of salt-water was gradually encroached upon, and at length converted into a muddy estuary, by detritus brought down from the interior of the country, and in which carcases of land-animals floated and ultimately became engulphed in the silt. It is in these last deposits, which now form the immediate subsoil of the Pampas, that the teeth of the *Megatherium*, *Mylodon*, *Glyptodon*, *Mastodon*, Horse, &c. have been found †

The MEGATHERIUM (*Petrif.* p. 478, *Lign.* 112, 113; *Wond.* p. 167; *Bd.* p. 139, and pl. v.) is the best known to the general reader, from the graphic exposition of its configuration and habits by Dr. Buckland, and the splendid remains of its skeleton presented to the Hunterian Museum by Sir Woodbine Parish; but this animal is only one of several species of *Edentata*, equally interesting, and almost rivalling it in magnitude, which the labours of our own naturalists, Sir W. Parish, Mr. Darwin, and Mr. Pentland,

* See "Buenos Ayres," &c., by Sir Woodbine Parish, 1852, pp. 209—223.

† See the charming volume entitled, "Journal of the Voyage of H. M. S. *Beagle*," by Charles Darwin, Esq; see also Prof. Owen's descriptions in the "Zoology of the *Beagle*," and his Report, laid before the British Association in 1847.

and of Dr. Lund and other foreign savants, have brought to light. I can only advert to two other genera, namely, the *Glyptodon* and *Mylodon*.*

GLYPTODON (*sculptured-tooth*) CLAVIPES. *Lign.* 264.— The bony tesselated carapace, or shield, which was formerly assigned to the Megatherium (*Bd.* i. p. 159) has been proved,† by the discovery of other specimens, to belong to a gigantic animal, whose bones are occasionally found associated with those of the Megatherium, and which is closely allied to the Armadillo. This discovery was made by my friend, Sir Woodbine Parish, to whose indefatigable exertions the Hunterian Museum is indebted for its most splendid relics of fossil Edentata.‡ The bony dermal coat of the Glyptodon (a fine specimen of which is in the Hunterian Museum) was not disposed in rings as in the Armadillo, but is made up of polygonal pieces, accurately articulating with each other, and continuous over the whole of the upper part of the body and part of the tail; the tail also is enclosed in a case of this kind, like a sword in its scabbard (*Petrif.* p. 359, *Lign.* 75).

The teeth of this animal, which are eight in number on each side of each jaw, are sculptured laterally, by two wide and deep channels (*Lign.* 264, *fig.* 1), which divide the grinding surface of the tooth into three portions (*Lign.* 264, *fig.* 2). The hind foot is very peculiar (see *Lign.* 264, *fig.* 3), presenting an extreme modification of the same general plan of structure as that of the Armadillo. The

* An able memoir in the Penny Cyclopædia, Art. MEGATHERIDÆ, and another under the title "UNAU," will present the student with an epitome of all that is at present known of these extinct beings.

† See *Geol. Trans.* 1835, p. 438, &c.; and Prof. Owen's elaborate Memoir on the Glyptodon in *Geol. Trans.* 2d ser. p. 81, pl. x.—xiii.

‡ A restored figure of the Glyptodon, together with the skeletons of the Megathere and the Mylodon, are beautifully illustrated in the interesting volume on "Buenos Ayres and the Provinces of Rio de la Plata." 2d Edit. By Sir Woodbine Parish, K. C. H. &c.

skeleton of this animal constitutes the type of a distinct genus (*Glyptodon*), related to the Armadillo (*Dasypus*).

LIGN. 264. GLYPTODON CLAVIPES.

Tooth and Bones of the Left Foot of a colossal Quadruped allied to the Armadillo (*reduced size*).

Pleistocene, near Monte Video.

Fig. 1.—Side view of a tooth, showing the deep lateral channels. The original four inches long.
2.—Grinding surface of the same.
3.—Outside view of the left hind-foot. Length of the original about fourteen inches, from the heel to the toe.

(*From the Geol. Trans.* 2d. ser. vol. vi. pl. x.)

MYLODON.*—By this name is designated a gigantic edentate animal, allied to the Sloth, and formerly described as a species of Megalonyx, an almost perfect skeleton of which has been obtained from a fluviatile deposit, a few leagues to the north of the city of Buenos Ayres, and is now articulated

* Signifying *molar-tooth*,—a name intended to express that the animal has only teeth adapted for grinding; but this term is equally applicable to all the other megatheroid animals.

and exhibited in the Museum of the Royal College of Surgeons of England.* The animal appears to have been imbedded entire, and soon after its death, for the parts of the skeleton were found but little displaced, and the very few bones that are wanting, are such as might easily have escaped the search of the collector. But this magnificent specimen of the extinct fauna of South America must be seen to be properly appreciated. The skeleton measures eleven feet from the fore part of the skull to the extremity of the tail, the latter being three feet in length; the circumference of the trunk around the tenth pair of ribs is nine feet nine inches; the Megatherium is eighteen feet in length, and its girth fourteen and a half feet. These particulars will serve to convey an idea of the relative size of these gigantic animals. From certain peculiarities in the construction of the skeleton of the Mylodon, Prof. Owen, perceiving from the teeth that it was a vegetable feeder, and probably lived on leaves and the tender buds of trees, and its enormous bulk and weight forbidding the assumption that it climbed up trees and suspended itself by the branches, like the diminutive existing Sloths,—assigns to this creature the task of uprooting and felling trees, and feeding upon the foliage of the forests it laid prostrate. A remarkable development of the substance of the bones of the skull is presumed to have been a provision against the fatal effects of a fracture of the cranium, to which the Mylodon, from its supposed uprooting propensities, is conjectured to have been peculiarly exposed; and the skull of the specimen in the College bears proofs of having had

* See "Description of the Skeleton of an extinct gigantic Sloth (*Mylodon robustus*)," &c., by Richard Owen, F.R.S. Hunterian Professor of the Royal College of Surgeons, 1 vol. 4to. with twenty-four plates, 1842. The lithographs in this work, by Mr. Scharf, are of the highest excellence: the figure of the entire skeleton of the animal, on a scale of two inches to a foot, is admirable.

two fractures, from both of which the animal recovered. But whoever looks at the skeleton will perceive that the fore-feet are admirably adapted for seizing and wrenching off the branches, and the hinder feet for clasping the trunk of a large tree; and there is nothing to forbid the supposition, that the animal could obtain a constant and ready supply of food, by climbing up the stem to a sufficient height, and wrenching off the branches. Prof. Owen states, that the Mylodon unites the two great groups of the *Unguiculata* (animals with nails and claws), and the *Ungulata* (hoofed animals), for it has both hoofs and claws on the same feet.

The dental organs consist of four molars on each side the lower, and five on each side the upper jaw. The teeth are implanted in very deep sockets, and are of the same size and form throughout, with a conical pulp-cavity at the base, indicating that their growth continued during the life of the animal. In structure they resemble those of the Megatherium and Sloth (*Bradypus*); being composed of a pillar of coarse dentine, traversed by numerous vascular or medullary canals, which is invested with a layer of very fine, dense dentine, with minute calcigerous tubes, and the whole surrounded by a thick coating of cementum: no enamel enters into their composition. (*Owen.*)

V. Fossil Rodents.—Of the mammalia termed *Rodentia* or Gnawers (see *Wond.* p. 143), of which the Mouse, Rabbit, and Beaver are examples, the remains of several genera are found in a fossil state; particularly in the caverns containing the bones of Carnivora. Dr. Buckland collected from Kirkdale Cave bones of a species of Hare or Rabbit, Mouse and Water-Rat (*Reliq. Diluv.* pl. xi.).

In the eocene gypseous strata of France, two species of Dormouse and two of Squirrel have been found. From the tertiary sand at Epplesheim, with the bones of the Dino-

therium, those of a species of Hamste or German Dormouse (*Cricetus*) were obtained.

Fossil teeth of a species of Porcupi e (*Hystrix*) occur in the pleiocene deposits of Tuscany.

Of the Beaver (*Castor*), some undoubted remains have been collected in this country. Those of a species apparently identical with the recent Beaver of the Danube, have been discovered in the fresh-water deposits of Essex,* Norfolk, Cambridgeshire, and Berks, and in Scotland; and the remains of the very large extinct species first observed in Russia (and named, by M. Fischer, *Trogontherium*,) have been found in the subterranean forest at Bacton, in Suffolk.†

VI. Fossil Marsupialia.‡—That the remains of an extinct species of gigantic *Kangaroo* should be found in the fissures of the rocks and in the caverns of Australia, a country in which marsupial animals are the principal existing mammalia, is a fact that will not excite much surprise; but that beings of this remarkable type of organization should ever have inhabited the countries situated in the latitude of the European continent and of Great Britain, would never have been suspected, but for the researches of the geologist. The fossil remains of this class discovered in Australia § occur in the pleistocene deposits of Darling Downs, Melbourne, &c. and in fissures and caves in the limestone of Wellington Valley, imbedded in red ochreous loam, and are often incrusted by stalactitic concretions. One of the species exceeds the largest existing Kangaroo,

* See Mr. Brown's Paper on Copford, *Quart. Geol. Journ.* vol. viii. p. 188.

† See *Hist. Brit. Foss. Mam.* p. 184, &c.; *Quart. Journ. Geol. Soc.* vol. iv. p. 42; and *Petrif.* p. 357.

‡ Marsupialia; animals that carry their young in a pouch (*marsupium*), as the Kangaroo.

§ Rep. Brit. Assoc. 1844, p. 223.

and its bones are associated with those of the Wombat, and other marsupial animals (*Ly.* p. 155).

A species of Didelphys (*Opossum*) has been discovered in the gypseous limestone of Montmartre, and is figured and described by Cuvier (*Oss. Foss.* vol. iii. pl. lxxi. ; see also *Brit. Foss. Mam.* p. 76). It consists of a considerable part of the skeleton of a small animal, imbedded in gypsum ; the block containing the specimen has been split asunder, and some of the bones are attached to the surface of one moiety, and the remainder to the other. From the character of the jaws and teeth, Cuvier pronounced that the animal was related to the Opossum, and confidently predicted that the two peculiar bones which support the pouch in these animals would be found attached to the fore-part of the pelvis ; accordingly he chiselled away the stone, and disclosed these *marsupial* bones ; thus proving the truth of those laws of correlation of structure, which he was the first to enunciate and establish. But as there are true marsupials in which the *ossa marsupialia* are merely rudimentary, for example, in the Dog-headed Opossum, or " Hyæna" of the Tasmanian colonists (*Thylacinus Harrisii*), in which they are merely two small, oblong, flattened fibro-cartilages, imbedded in the internal pillars of the abdominal rings, and are only six lines long and three or four lines broad,—it follows that in a fossil state the pelvis of a true marsupial animal may be destitute of those appendages which are commonly supposed to be an essential character of the marsupial skeleton. Thus the fossil pelvis of the Thylacinus, had that species been long ago, as it is soon likely to be, extinct, would not have afforded the certain evidence of its marsupial character to which Cuvier triumphantly appealed in demonstration of the Didelphys of the gypsum quarries of Montmartre ; yet the Thylacinus would not therefore have been less essentially a marsupial animal.*

* See Prof. Owen, *Zoological Society's Proceedings*, Dec. 1844.

In the Eocene sand at Kyson, near Woodbridge, in Suffolk, among other mammalian remains (*Ly.* p. 203), Mr. Colchester, of Ipswich, whose researches have been rewarded by many interesting fossils, found a fragment of the jaw, with one premolar tooth having two fangs, of a small animal (*Didelphys Colchesteri*, Owen); and which Mr. Charlesworth (Curator of the Philosophical Institution of York) ascertained to belong to a marsupial animal allied to the Opossum.*

But the specimens above described are far surpassed in interest by those discovered in the Triassic Bone-bed of Wurtemberg and in the Oolite of Stonesfield; the latter consisting of several jaws and teeth of marsupial animals.

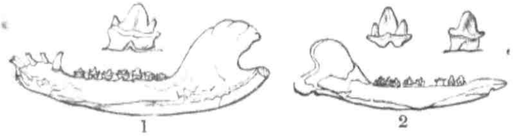
TRIASSIC MAMMALIAN TEETH.—In the thin layer of rolled bones, teeth, scales, and coprolite, so extensively spread over the top of the Trias and at the base of the Lias, both in England and in Wurtemberg, and well known to collectors as the "Bone-bed" of Aust Cliff, &c. (*Wond.* p. 529), a few minute *mammalian* teeth have been discovered by M. Plieninger at Diegerloch, near Stuttgart, Wurtemberg. They appear to have belonged to one or more small Insectivorous quadrupeds, and have been described by Plieninger and Jäger. Sir C. Lyell, in the Prefatory Note to his Manual, 1852, fully treats of these interesting and most ancient mammalian remains, and gives several exact figures of the teeth.

FOSSIL MAMMALIA OF STONESFIELD.† *Lign.* 265. (*Bd.* pl. ii. *Ly.* p. 268. *Wond.* p. 510.)—The best known examples of the fossil remains of mammalia in the Secondary formations, and, excepting the teeth just mentioned, of the highest antiquity, according to our present knowledge of

* See *Mag. Nat. Hist.* 1839, p. 450; *Rep. Brit. Assoc.* 1842, p. 73; and *Brit Foss. Mam.* p. 71, fig. 22.

† See Owen's *Brit. Foss. Mam.* pp. 29—70, figs. 15—20; and *Petrifactions*, p. 401, *et seq.*

the earth's physical history, are several mutilated lower jaws with teeth, of some very small animals, which are supposed to belong to insectivorous marsupial quadrupeds.*



LIGN. 265. LOWER JAWS OF MAMMALIA; *nat.*

Great Oolite. Stonesfield.

Fig. 1.—PHASCOLOTHERIUM BUCKLANDI. The right branch of the lower jaw, seen from within, with seven grinders, one canine tooth, and three incisors.

2.—AMPHITHERIUM BRODERIPII. The left branch of the lower jaw, the inner side; the incisor and canine teeth are wanting.

The upper figures are enlarged views of three molar teeth.

(*Geol. Trans.* 2d ser. vol. vi. pl. vi.)

These most important organic remains have all been found in the oolitic calcareous flag-stones of Stonesfield; deposits which, as we have already had occasion to notice, teem with other relics of great interest. Two specimens of the natural size are represented *Lign.* 265, and will serve for reference to the collector who may visit that interesting locality.

The existence of undoubted mammalia in the secondary formations was first made known by Dr. Buckland (in 1823), who, upon the authority of Cuvier, stated that the two specimens then discovered at Stonesfield belonged to marsupials allied to the Opossum (*Didelphys*). These fossils were the left branches of two lower jaws; both were imbedded in the stone by the external surface, the inner side only being exposed. One of the specimens has ten molar teeth in a row; the other (the beautiful fossil, *fig.* 1, *Lign.*

* A small mammalian vertebra from Stonesfield is in Mr. Morris's collection, and has been figured by Mr. Bowerbank, *Quart. Geol. Journ.* vol. iv. pl. i. fig. 4, and pl. ii. fig. 6.

265, now in the British Museum,) has seven molars, one canine tooth, and three incisors. Five other specimens have since been found.*

The *Amphitherium* had thirty-two teeth in the lower jaw, that is, sixteen on each side; it is presumed to have been insectivorous, and to have belonged to the *placental* mammalia. The *Phascolotherium* had four true molar teeth, and three or four false molars, one canine, and three incisors in each branch of the lower jaw; and closely approximates to *marsupial* genera now restricted to New South Wales and Van Diemen's Land. It is, indeed, as Professor Phillips first remarked, an interesting fact, that the other organic remains of the British Oolite correspond with the existing forms now confined to the Australian continent and neighbouring seas; for in those distant latitudes, the *Cestracionts*, *Trigoniæ*, and *Terebratulæ* inhabit the ocean, and the *Cycadeæ* and *Araucariæ* flourish on the dry land (*Wond.* p. 894).

Thus we have evidence of the existence of the Marsupial order during the Secondary and Tertiary formations; a proof, as Dr. Buckland observes (*Bd.* p. 73), that this order, instead of being, as was once supposed, of more recent introduction than other orders of mammalia, was, in reality, the most ancient condition under which animals of this class first existed in the earlier geological epochs, and was coexistent with many other orders throughout Europe in the Eocene period; while its geographical distribution in the existing fauna is restricted to North and South America, and to New Holland, and the adjacent islands.

VII. Fossil Carnivora.—The fossil bones and teeth of numerous species of *Carnivora*, the order comprising the mammalia which prey on other animals, of which the

* See *Brit. Foss. Mam.* pp. 15—70, for ample details of their anatomical characters, and physiological relations.

Weasel, Bear, Cat, Dog, &c. are examples, abound in fissures and caverns, in conglomerated rocks, and in drifted sand and gravel. The remains of the colossal Pachyderms, the Mastodons and Elephants, lie buried, for the most part, as we have previously shown, in the superficial alluvial deposits; but the Carnivora, although occasionally entombed, with the Herbivora in superficial gravels and loams, are principally found imbedded in the floors of extensive caverns.* In many instances, such immense quantities of bones and teeth of individuals of all ages, and belonging to but one or two species, occur in certain caves, as to render it probable that these were for a long period the dens of the extinct species of Bears, Hyænas, &c. whose bones they enclose.

Another remarkable geological condition in which fossil bones of Carnivora occur, is that of an ossiferous conglomerate, or *bone-breccia;* that is, a conglomerate formed of fragments of limestone and bones, cemented together into a hard rock by a reddish calcareous concretion. This breccia is found in almost all the islands on the shores of the basin of the Mediterranean Sea; as for example, at Gibraltar, Cette, Nice, Cerigo, Corsica, Palermo, &c. The most celebrated of the bone-caves are situated in Franconia, and in many parts of the Hartz. That of Gailenreuth has long been known for its fossil treasures, which principally consist of the bones and teeth of two extinct species of Bears. One of these is equal in size to a large horse, and is termed *Ursus spelæus* (Bear of the Caverns); and skeletons have been found of all ages, from the adult to the cub but a few days old (see *Wond.* pp. 176, 177). There are numerous caverns in the neighbouring district, some of which are equally rich in the remains of Carnivora.† Similar fossils are also

* *Rep. Brit. Assoc.* 1842, sect. p. 62. For an account of the ossiferous caves of the Brazils, see *Petrif.* p. 483.

† A highly interesting account of the Ossiferous Caves of the

found in the consolidated gravel and drift in various parts of Germany, and in the fissures of rocks containing iron-ore, at Kropp, in Carniola.

Even in Australia, caves with ossiferous breccia are numerous; but the bones belong to extinct marsupial animals of genera still existing in the country (see *Rep. Brit. Assoc.* 1844; *Petrif.* p. 133; and *Wond.* p. 188). In England, several caverns presenting similar phenomena have been discovered. That of Kirkdale, near Kirby Moorside, Yorkshire, is well known from the celebrity it acquired by the graphic illustration of its contents by Dr. Buckland.* This cave, or rather fissure, for its dimensions were too limited to merit the name of cavern, was situated in oolitic limestone; it was two hundred and fifty feet long, from two to fourteen high, and six or seven wide. The floor was occupied by a bed of indurated mud, covered over with a thick crust of stalagmite; the roof and sides being invested with a similar calcareous sparry coating, as is commonly the case in all fissures in limestone rocks.† From this cave were obtained numerous bones of Hyænas, associated with bones, more or less fractured, of Tiger, Bear, Wolf, Fox, Weasel, Elephant, Rhinoceros, Hippopotamus, Horse, Deer, Ox, Hare or Rabbit, Mouse, Water-rat, and fragments of skeletons of Ravens, Pigeons, Larks, and Ducks. Many of the

Hartz and Franconia, by Sir Philip Grey Egerton, Bart. was published in 1834, *Geol. Proc.* vol. ii. p. 94. See also Captain Montagu's notice of the Sophienhöhle further on, at p. 820.

* Dr. Buckland's celebrated work, "Reliquiæ Diluvianæ," contains an admirable description of these caverns and their contents, with numerous plates. The student, in consulting this volume, must separate the *facts* from the diluvial theory, which, at the period of its publication (1823), they were supposed by Dr. Buckland and other eminent geologists to confirm.

† For a general description of the cave at Kirkdale, see *Wond.* p. 179; and for details, *Reliq. Diluv.* pp. 1—19. The ossiferous caves at Kirkdale, Torquay, and Banwell are noticed, *Petrif.* p. 482.

bones exhibited marks of having been gnawed, and crushed by the teeth of some animals. From all the facts observed, and which are detailed by Dr. Buckland with his wonted graphic power, it is inferred that the cave was inhabited for a considerable period by Hyænas; that many of the remains found there were of individuals carried in and devoured by those animals, and that in some instances the hyænas preyed upon each other. The portions of bone referable to the elephant seem to prove that occasionally the large mammalia were also obtained for food; but it is probable that the smaller animals were either drifted in by currents of water, or fell into the chasm through fissures now closed up by stalactitical incrustations.

Kent's Cave, near Torquay, Oreston Cave, near Plymouth, and several other caves in Devonshire, have yielded great numbers of bones and teeth of Carnivora and Pachydermata (see *Reliq. Diluv.* p. 67).

KENT'S HOLE is the most productive ossiferous cavern in England, and its vicinity to Torquay renders it of easy access. An extensive collection of teeth and bones was obtained from this cave by the late Rev. J. MacEnery, comprising, in addition to the usual extinct Carnivora, skulls and teeth of Badger (*Meles taxus*), Otter (*Lutra vulgaris*), Pole-cat (*Putorius vulgaris*), Stoat or Ermine (*P. erminius*), &c. A selection of the choicest specimens in this collection is deposited in the British Museum.

In Glamorganshire, two large caverns, called Goat's Hole, and Paviland Cave, containing numerous bones of Bear, Hyæna, Wolf, Fox, Rhinoceros, Elephant, &c., are situated in a lofty cliff of limestone, between Oxwich Bay and the Worm's Head, on the property of Earl Talbot, fifteen miles west of Swansea (*Reliq. Diluv.* p. 82).

In the western district of the Mendip Hills, in Somersetshire, there are several ossiferous fissures and caves. The most interesting are those of Hutton, on the northern

escarpment of Bleadon Hill; and of Banwell, lying about a mile to the east of Hutton. They contain remains of two species of bear, one (*Ursus spelæus*) of immense size and strength; and of Tiger, Hyæna, Wolf, Fox, Deer, Ox, and Elephant.*

From the caves at Hutton, the Rev. D. Williams obtained the milk-teeth and other remains of a calf-elephant, about two years old, and those of a young tiger, just shedding its milk-teeth; also the grinders of a young horse, that were casting their coronary surfaces; and remains of two species of hyæna.

But one instance of the fossil bones of Carnivora has been observed in the south-east of England. It occurred in a fissure in a quarry of sandstone at Boughton, near Maidstone; among other bones, the lower jaw of a Hyæna (see Frontispiece of Vol. I.), with the teeth, was obtained.†

In the modern silt of our alluvial districts, the remains of carnivorous animals, formerly indigenous to this island, are occasionally met with; and the skeleton of the Brown Bear (a species which inhabited Scotland eight centuries ago), and of the Wolf, whose extinction is of a yet later date, have been discovered. The Woodwardian Museum at Cambridge contains an entire skull of the Brown Bear (*Ursus arctos*), found in the Manea Fen of Cambridgeshire;‡ in an ancient fresh-water deposit, near Bacton, in Norfolk, the right lower jaw of the Bear of the Caverns (*Ursus spelæus*), has been discovered;§ and the phalangeal bone of a large Bear has been found by Mr. J. Brown in the pleistocene deposits at

* See a Memoir "On the Caverns and Fissures in the Western District of the Mendip Hills," by the late Rev. D. Williams. Proc. Royal Society, June 2, 1831, p. 55.

† See *Mag. Nat. Hist.* 1836, vol. ix. p. 593; and *Quart. Journ. Geol. Soc.* vol. vii. p. 383.

‡ A beautiful lignograph of this specimen is given in *Hist. Brit. Foss. Mam.* p. 77, fig. 24.

§ Hist. Brit. Foss. Mam. p. 89.

Copford, Essex, with the remains of Beaver, Elephant, Stag, &c. (*Geol. Journ.* vol. viii. p. 187.)

Thus the remains of fossil Carnivora discovered in England comprise several kinds of Bear* (including the two species of the caverns of Germany, *U. priscus* and *U. spelæus*), and of Tiger, Hyæna, Wolf, Fox, &c.

Although we cannot dwell on foreign localities of Carnivora, I may mention that the lacustrine pliocene formation of Œningen occasionally yields fine remains. A splendid specimen, obtained from that locality by Sir R. I. Murchison, displays almost the entire skeleton of a Fox-like animal, the *Galecynus Œningensis* of Prof. Owen.†

The SEAL, which is one of the marine carnivorous mammalia, also occurs in a fossil state in England. A femur of a species of *Phoca* has been found, with the remains of a Monkey and Bat, in a tertiary deposit in Suffolk. In the tertiary strata of Malta an extinct species of Seal has also been discovered. In the bone-beds of New Zealand my son frequently found bones and teeth of Seals, probably of the species now inhabiting the South Pacific. (*Petrif.* p. 130.)

Of the INSECTIVORA, the fossil remains of several genera occur. In England, the jaw with teeth of a large species of *Mole* (named PALÆOSPALAX,‡ *ancient mole*), has been discovered in a lacustrine deposit at Ostend, near Bacton, on the coast of Norfolk, associated with bones of Elephant, Deer, Roebuck, and Beaver. This animal must have been as large as a hedgehog. The only part of the skeleton hitherto obtained is a portion of the left side of the lower jaw, containing six molars; its natural affinities have therefore been inferred from the characters of the crowns of the teeth.

* *Petrif.* p. 398. In the *Pict. Atlas*, pl. lxxiii., is a good figure of a large Bear's tooth. Teeth of Bear, Tiger, Hyæna, and Arvicola, are figured in *Ly.* p. 161.

† See *Geol. Trans.* 2d ser. vol. iii. pl. xxxiii.; and *Quart. Geol. Journ.* vol. iii. p. 55.

‡ Hist. Brit. Foss. Mam. p. 25.

The CHEIROPTERA (*hand-wings*) or BATS, are mammalia which have the power of flight, from the bones of the phalanges or fingers being enormously elongated and giving support to a fine membranous expansion; they are rarely found fossil, although, from their habits of haunting and hybernating in fissures and caves, their skeletons often occur mingled in the earth of the floor of caverns, and imbedded in crannies of rocks, with bones of extinct animals.

The remains of a considerable portion of the skeleton of one species of Bat was discovered by Cuvier in the gypsum of Montmartre,* and another example in a gypseous deposit, at Köstritz, in Germany, with remains of extinct species of other mammalia. Two instances of British fossil Bats are recorded;† the one from Kent's Cavern, collocated with the extinct Carnivora, and referred to the Horse-shoe Bat (*Rhinolophus*); the other from Kyson, in Suffolk, found in the same deposit with the remains of the Monkey, presently to be noticed.

VIII. FOSSIL QUADRUMANA, OR MONKEYS.—The illustrious Cuvier, when commenting on the extraordinary fact, that among the innumerable fossil relics of the mammalia which peopled the continents and islands of our planet, through the vast periods comprehended in the tertiary formations, no traces of MAN or of his works occur, emphatically remarked, that it was a phenomenon not less surprising, that no remains of the quadrumanous races, which rank next to Man in physical conformation, should have been found in a fossil state; and that the circumstance was the more remarkable, because the majority of the mammalia found in the younger and older tertiary strata have their congeners at the present time in the warmest regions of the

* Discours sur les Révolutions de la Surface du Globe, par Baron G. Cuvier, 4to. 1826, pl. ii. fig. 1.

† Rep. Brit. Assoc. 1842, and Brit. Foss. Mam. pp. 11—18.

globe; in those intertropical climates where the existing quadrumana are almost exclusively located.*

Fossil Ape of France.—But the remains of this order have at length been discovered in the most ancient of the tertiary deposits, and under circumstances which admit of no doubt as to the antiquity of the fossils or the strata in which they were imbedded; and almost at the same time in France and in the Sub-Himalayas; and very recently in the Brazils and in England. The first European specimen was discovered at Sansan, near Auch, about forty miles west of Toulouse, by M. Lartet, with remains of the Rhinoceros, Deer, Antelope, Palæotherium, &c. It consists of the lower jaw, almost complete, with all the teeth, of an adult animal, of an extinct species, related to the long-limbed and tailed monkey, called *Semnopithecus*, of which the Negro Monkey is an example. A fragment of another jaw has been found in the same locality.

Fossil Monkey of the Sub-Himalayas.—In the inexhaustible mine of fossil bones, discovered by British Officers in India, the upper jaw of an Ape was found by Messrs. Baker and Durand, and fragments of other jaws and some bones were subsequently collected by Dr. Falconer and Captain Cautley. These relics conjointly established the existence of a gigantic quadrumanous animal in the groves of India at the Eocene epoch, when the gigantic Tortoise, the lofty Sivatherium, and the colossal Mastodon tenanted the plains, and Hippopotami frequented the marshes and rivers. This fossil Ape also is related to the *Semnopithecus*.

Fossil Monkey of South America. — Dr. Lund, the eminent Danish naturalist, to whose indefatigable researches, and successful determination of the colossal Edentata, we have previously alluded, has discovered the bones of a

* Discours sur les Révolutions de la Surface du Globe, p. 171.

gigantic Ape, four feet in height, related to the Capuchin Monkey, in the ossiferous breccia of the caves of Brazil.

BRITISH FOSSIL MONKEYS, *Ly.* p. 202.—The first fossil relic of a quadrumanous animal from the British strata was obtained in 1839, from a bed of Eocene sand, at Kyson, a few miles east of Woodbridge, in Suffolk, by W. Colchester, Esq. The first specimen found consisted of a small fragment of the right side of the lower jaw, with the last molar tooth entire in its socket; another relic is the crown of one fang of the first molar tooth, of the same species. These relics have been referred to an extinct species of Monkey, related to the *Macacus*, which has been named *Macacus eocænus*, in allusion to the geological age of the stratum in which the remains were discovered.* In this Eocene sand have also been discovered the remains of a Bat (p. 813), and of a Marsupial (*Didelphys*, p. 805), and numerous fish-teeth (*Lamna*, p. 594); whilst in the clay overlying this sand were found the vertebra of a Serpent (*Palæophis*, p. 738) and several teeth of a Pachyderm (*Hyracotherium*, p. 791). Prof. Owen in the *Hist. Brit. Foss. Mam.* p. xlvi. figures and briefly notices the relics of another species of *Macacus*, from the newer pliocene, or pleistocene, brick earth at Grays, Essex.

FOSSIL HUMAN BONES.—In the Swabian Alps, human teeth and several perfect human skulls are said to have been found in deposits in which elephantine remains also occur. This subject was brought before the meeting of the German Association for the Advancement of Science at Tübingen, by Fraas and Jäger, and, if correctly reported, naturally leads to the conclusion that human beings were contemporaneous with the extinct elephants and some of the other large pachydermata in the regions referred to.

ON COLLECTING AND DEVELOPING THE FOSSIL REMAINS OF MAMMALIA.—But few directions for the developing and

* Owen, British Fossil Mammalia, p. 1, figs. 1, 3.

repairing of the fossil remains of mammalia will be required in this place, the suggestions already offered, and particularly those in vol. i. pp. 45—49, embracing full instructions on this head.* On the method recommended in p. 46, for strengthening the friable bones of the large mammalia, I may observe, that the *drying-oil* is prepared by boiling *litharge* in oil, in the proportion of one ounce of the litharge to a pint of oil.

The search for fossils of this class is attended with much less certainty of success than for other animal remains. In the following list, page 818, the localities most likely to be productive are enumerated; but we have no caverns, as in Germany, so rich in remains of this kind as to ensure the discovery of specimens by the casual visitor; for the treasures of the most productive cave, that of Banwell, are prohibited; the proprietor carefully preserving every fragment. A short residence near some of the best localities and daily research are required for obtaining interesting specimens. For example, a residence at Ryde, for a search in the fresh-water tertiary limestone at Binstead; at Torquay, for Kent's cavern; or some other town or village near the other caves in Devonshire; Herne Bay, for the London Clay at Studd's Hill, that produced the Hyracotherium; Woodbridge or Kyson, for the Suffolk mammalia; Walton and

* CEMENT. — The following formula was given me by an eminent collector and developer of fossils:—

Gum mastic, one ounce;

Rectified spirit of wine, sufficient to dissolve it.

Isinglass, one ounce, soaked in water until soft; then dissolve it in pure rum or brandy until it is in the state of stiff glue: add to this a quarter of an ounce of gum ammoniacum, well rubbed and mixed.

Put the two solutions together in an earthen vessel, over a gentle heat; when thoroughly melted and united, put the mixture into smooth, well-corked bottles.

Use.—Immerse the bottle in hot water until the cement is sufficiently liquid for use.

Clacton, in Essex, for remains of Elephants in the pleistocene deposits of that coast.

In searching for bones and teeth in an unexplored cave, the following suggestions by Dr. Buckland will be found of great value. Select the lowest parts in the cavern or fissure into which any mud or clay can have been drifted or accumulated; and then break through the stalagmitic crust of the floor, and dig down into the silt and pebbles, &c. below, in which bones and teeth will be found, if the spot contains any relics of this kind. As a test for distinguishing the ancient bones found in these caves from those which may have been recently introduced, the tongue should be applied to them when dry, and they will adhere in consequence of the loss of their animal gluten, without the substitution of any mineral substance, such as we commonly find in the fossil bones of the regular strata. Human bones found in caves always possess too much animal gluten to adhere to the tongue when dry.*

Along the eastern coast of England, and often off the mouth of the Thames, the fishermen dredge up teeth, tusks, and bones of Elephants; and good specimens may sometimes be thus procured. The Ramsgate fishermen employed in trawling in the North Sea and English channel, frequently bring up in their gear fragments of fossil bones of Mammoths, and other mammalia. From the bank of the Goodwin-sands, large tusks have been procured. On the shore near Herne Bay, very fine mammalian remains are occasionally obtained. In the Museum at Canterbury, there was (and I believe is) a good collection of fossil bones of large Pachydermata procured from the neighbouring coast. It is a remarkable fact, that immense quantities of the bones of Mammoths, or fossil Elephants, are strewn over the bed of the German Ocean and English Channel.† The late Mr.

* Dr. Buckland on Fossil Bones of Bears in the Grotto of Osselles, near Besançon, in France. *Geol. Proc.* vol. i. p. 22.

† Geol. Trans. 2d ser. vol. vi. p. 161.

Woodward informed me, that the teeth and tusks of Elephants collected along the Norfolk and Suffolk coasts, within his own cognizance, must have belonged to upwards of five hundred individuals.

BRITISH LOCALITIES OF FOSSIL MAMMALIA.

Bacton, Norfolk. See *Ostend.*

Banwell Cave, fifteen miles from Bristol, and three from Banwell Station. Bones and teeth of Bears, Hyænas, a Felis larger than the Lion; but chiefly of Deer and Oxen.

Berry Head, Devonshire; Cave. Carnivora; as Bear, Badger, Tiger, Pole-cat, Stoat.

Binstead, near Ryde, Isle of Wight. *Upper Eocene.* Fresh-water limestone. Teeth and bones of Anoplotherium, Palæotherium, Chæropotamus, Dichobune.

Brighton Cliffs. Between Kemptown and Rottingdean, in the beds above the Chalk. *Pleistocene.* Teeth and bones of Elephant, Horse, Deer, Oxen; jaw of a Whale.

Copford, Essex. *Pleistocene.* Elephant, Stag, Ox, Beaver, Bear, &c.

Crayford, Kent. *Pleistocene.* Elephant, Horse, &c.

Easton, a mile and a half north of Southwold. Mastodon tooth, and Carnivora.

Folkestone, Kent. *Pleistocene.* On the top of the west cliff and in the valley; bones of Elephant, Hyæna, Hippopotamus, Ox, Horse, Stag, &c. (*Quart. Geol. Journ.* vol. vii. p. 257.)

Grays, Essex. *Pleistocene.* Elephant, Monkey, &c.

Harwich, Essex. *Pleistocene.* Elephant's teeth, &c.

Herne Bay. In *London Clay;* Hyracotherium, Chæropotamus. In *Pleistocene* deposits; Elephant, Whale.

Hoe, near Plymouth, raised Beach at. *Pleistocene.* Elephant, Rhinoceros, Bear, Deer, Whale, &c.

Horstead, Norfolk. *Pleistocene.* Mastodon tooth.

Hutton Caves, near Banwell, Somersetshire. Carnivora, Pachydermata, &c. See p. 783.

Isle of Man. *Pleistocene.* The gigantic Irish Deer (*Cervus megaceros.*)

Kent's Cave, near Torquay. The most productive of the British ossiferous caverns (see p. 813). Bear, Badger, Tiger, Wolf, and other Carnivora; Rhinoceros, Elephant, and other Pachydermata.

Kirkdale, by Kirby Moorside, Yorkshire (see p. 783). I know not if any accessible part of this celebrated cave remains.

Kyson, near Woodbridge, Suffolk. On the side of the river Deben, about a mile from Woodbridge, in the parish of Kyson (Kingston). The strata consist of, 1. Red crag, the uppermost. 2. London clay, about twelve feet. 3. White and yellow sand. In this lower *Eocene* bed the relics of *Monkey*, *Didelphys*, and *Bat*.

Manea Fen, Cambridgeshire. *Pleistocene*. Skull of Bear.

Newbourn, Suffolk. *Pleistocene*. Mastodon tooth. Leopard.

Newbury, Berks. *Pleistocene*. In the peat and shell-marl, Boar, Ox, Roebuck, Stag, Beaver, Wolf, Ass, &c.

Norwich. *Pleistocene*. Mammoth's teeth and bones.

Oreston Cave, near Plymouth. Carnivora, Wolf, Bear, Hyæna, &c.

Ostend, near Bacton, on the coast of Norfolk. In a lacustrine deposit of dark clay and greenish sand, with charred trunks and branches of trees. A section presents — 1. Uppermost: Drift. 2. Black earth, with shells. 3. Reddish sand. 4. Norwich crag, in patches. 5. Chalk. Nos. 2 and 3 are lacustrine; and in these *Pleistocene* beds have been found Gigantic Mole (*Palæospalax*), Elephant, Deer, Roebuck, fossil Beaver (*Trogontherium*), jaw of Bear (*Ursus spelæus*). See Hist. Brit. Foss. Mam. p. 85.

Paviland Cave, fifteen miles west of Swansea; between Oxwich Bay and the Worm's Head, Glamorganshire. Rhinoceros, Mammoth, Hyæna, Wolf.

Plymouth. Caverns near elevated Beach, at the Hoe. Elephant, Rhinoceros, Bear, &c.

Postwick, near Norwich. *Pleistocene*. Tooth of Mastodon.

Seafield, Isle of Wight. *Upper Eocene*. Palæotherium.

Southbourn, Sussex. *Pleistocene*. The plain of alluvial mud and clay, called the "*Wish*:" a section seen on the sea-shore between the Sea-houses and the foot of the chalk hills. Elephant, Hippopotamus, Deer, Horse, Ox.

Southwold, Suffolk. *Pleistocene*. Elephant, Rhinoceros, Horse, Deer, Mastodon: Otter, in *Red Crag*.

Stonesfield, near Woodstock, Oxfordshire. *Great Oolite*. The only known locality in England of remains of mammalia of the Secondary period. See p. 805.

Studd Hill, a mile westward of Herne Bay. London clay. *Hyracotherium*.

Swansea (Paviland Cave, near). See Paviland.

Wirksworth, Dream Cave. A perfect skull of Rhinoceros; in Dr. Buckland's museum, at Oxford.

Woodbridge, Suffolk. At Kyson, near Woodbridge. *Eocene.* Teeth of Monkey, &c.

Note.—For notices of the occurrence of Mammalian Bones at Betchworth, Brighton, Dover, East Bourn, Folkestone, Maidstone, Marden, Peasemarsh, the valley of the Wey, Stonesfield Slate, Thames Valley, &c., see *Quart. Journ. Geol. Soc.* vol. vii. (consult Index). Of foreign localities, Tibet, Upper Punjab, Siwalik Hills, Vichy, &c., are also referred to in the same volume.

BONE CAVES IN FRANCONIA.

*** CAPTAIN WILLOUGHBY MONTAGU having favoured me in 1844 with an account of the state of the principal caves in Franconian Switzerland, which he had lately visited, the subjoined extract may be useful to the continental traveller. The cave of *Gophienhöhle* appears to be highly interesting; the stalactites remaining uninjured, and the ossiferous floor in the state in which it was discovered; whilst the much-frequented caverns have been stripped of every relic by the spoliations of visitors during the last century and a half.

"The northern part of Bavaria, which is denominated 'Franconian Switzerland,' is situated about the centre of a triangle, formed between Bamberg on the N.W., Bayreuth N.E., and Nuremberg S.; the best road from this latter city diverging beyond Erlangen to the north.

"The nearest route from London is through Belgium, from Ostend or Antwerp, by the line of railroad which (since October, 1843) passes on from Liege and Verviers, by Aix-la-Chapelle to Cologne. Thence by steam up the Rhine, by Coblentz to Mayence, and again by railway to Frankfort. In summer there are steam-boats up and down the Maine, as far as Wurzburg, daily, and higher up, between Schweinfurt and Bamberg, which latter distance is performed in eight hours going up, and five down. Or there is a diligence (*eilwagen*) from Frankfort direct to Nuremberg, from which place (or Bamberg, &c.) a carriage must be hired to Muggendorf, the principal village of that interesting district. It lies about half way on the post road between Erlangen and Bayreuth, and has two tolerable country inns; the people are civil, and moderate in their charges, at least for the freshest trout and good wine of Bavaria.

"This charming spot and neighbourhood attracts not only the geologist and lover of the picturesque, but also the angler, who finds

excellent fishing in the clear, rapidly-winding streams of the Wiesent, with its tributary waters, all of which are romantically placed in the suddenly deep dales of this table-land. The Wiesent flows through Forchheim into the Regnitz, westward, and this into the Maine, north.

"As to the time necessary to get there, during the summer days it would only require one to pass through Belgium to Aix, including the transit of this frontier into Prussia, with slight search of baggage. Then, in between four and five hours to Cologne, where the steamers generally wait for the arrival of these trains; and, taking the first boat up, it is possible to reach Bingen (if not Mayence late) the same evening. From Frankfort, by diligence, starting at 11 A.M., and travelling all night, Nuremberg may be reached on the second day; and the centre of operations, about Muggendorf, on the fifth from quitting the sea-coast. In returning by the Maine,—from Wurzburg to Mayence may be performed in one long day, and then on the Rhine, the descent being much quicker than the upward course against the streams, the return homewards may be accomplished in one day less.

"The nearest way to Ostend is by the South-Eastern Railroad to Dover, and embark for Belgium.

"The newly-discovered cave, called *Sophienhöhle*, lies on the right bank of a streamlet, which gives its name to a romantic and rocky valley, *Ahorn-thal*, and flows S.W. toward Gösweinstein, until it falls into the Wiesent. The situation of the cave is near Klausteinerhöhle, and opposite to Ludwigshöhle: and it is far easier of access than Gailenreuth, and may be inspected by ladies with the greatest facility. An intelligent female showed us through its lofty and interesting details. This cave is nearly 300 feet wide, and 150 feet in height. The quantity of fossil bones strewed about the floor was very great, notwithstanding many of the finest specimens had been removed, and were to be seen in the neighbouring castle of Count S——; added to this, the long, pendant curtains of stalactite, and the stupendous size of the cavern, contributed to make it appear to me far surpassing in interest that near Gailenreuth, called *Zoolithen-Höhle*, which I had visited the day before. The keys of this cavern—for this, as well as the other celebrated caves, is locked up, to guard against depredations—are kept at the large farm or steward's house, hard by. The state of the weather prevented our visiting Förstershöhle (*Forest Cavern*), which lies further N.E. beyond the little town of Weischenfeld, near Zeubach; but which, we were informed, was equal in interest to this of Sophienhöhle. The tourist desirous of visiting this interesting district, will find Mr. Murray's Handbook of Southern Germany an excellent guide: I can vouch for its accuracy."

RETROSPECT.

"*Ce que nous connaissons est peu de chose; ce que nous ignorons est immense.*" LA PLACE.

WE have now arrived at the close of this argument; we have taken a general survey of the fossilized relics of the various classes of the animal and vegetable kingdoms, and have explained the methods by which the inscriptions on these "Medals of Creation" may be deciphered.

But numerous as are the facts that have passed in review before us, and great as the accession of geological knowledge has been during the last fifty years, the data hitherto obtained are insufficient to elucidate many of the obscure pages of the earth's physical history; and to future discoveries must be left the full interpretation of many phenomena as yet obscurely presented to us.

In vain we endeavour to penetrate the veil which shrouds from our view many of the mighty events that preceded the history of our race, for,—although the shades of colossal and unknown forms belonging to the remote ages of a past eternity obey the spell of the true magician *Science*,—yet of the innumerable beings which through countless centuries

> "The Earth has gather'd to her breast again,
> And yet again, the millions that were born
> Of her unnumber'd, unremember'd tribes—"

how few, comparatively, could even the transcendent genius of Cuvier reveal!

If we endeavour to trace the order of succession, in which the extinct and existing types of animal and vegetable organization have appeared upon the face of our globe, as demonstrated by fossil remains, we at once perceive how imperfectly our knowledge enables us to present a true picture of the development of organic life as it existed in the remotest ages. Ascending from the *Granite*—that shroud which conceals for ever from human ken the earliest scenes of the earth's physical drama—the first glimpses we obtain of animated nature are a few sea-weeds, shells, and crustacea. But can we doubt for a moment that *that* ancient sea had its boundaries and its shores—that then, as now, there were islands and continents, and hills and valleys, and streams and rivers, teeming with appropriate inhabitants? The little Lycopodiaceous seed-vessels in the Ludlow bone-bed afford as certain indication of dry land, as the olive branch which the dove brought back to the Ark: one fact of this kind overthrows a host of theories based upon negative evidence.

Throughout the lower palæozoic rocks organic life presents numerous modifications; and the remains of small placoid fishes appear in the uppermost Silurian. In the Devonian we meet with rare reptilian remains and foot-prints. In the Carboniferous rocks the sauroid Batrachians have left their relics and their foot-tracks. In the succeeding period these reptiles predominate; and on the sands of the Triassic ocean we have the foot-prints of monster reptiles and the tracks of bipeds—colossal bird-footed creatures—of which no other vestiges remain, and to which the existing order of creation affords no parallel.

The last bed of the Trias affords the first indication of Mammalian life.

We now enter upon that marvellous epoch, during which

reptilian organization obtained its fullest development—when the Iguanodon and Megalosaurus—

> "Mighty Pre-Adamites who walked the earth,
> Of which ours is the wreck—" BYRON.

were the principal inhabitants of vast islands and continents. But here, as at an earlier period, we have proof that warm-blooded animals existed; and the diminutive marsupial insectivorous Mammalia of the Oolite and the birds of the Wealden attest that the system of animal creation was complete.

Leaving behind us the Age of Reptiles, we approach that of the colossal Mammalia, when extensive countries were peopled by the enormous herbivorous Megatheres, the Mastodons, and gigantic Pachyderms, long since become extinct. But with these lost forms many existing races were contemporary; including the Monkey tribes, which, of all animals, approach nearest to man in their physical organization. Thus, by slow and almost insensible gradations, we arrive at the present state of animate and inanimate nature. But even after the existing continents had attained their present configuration, in the period immediately antecedent to the human epoch, innumerable tribes of carnivorous animals swarmed throughout the temperate climates of Europe; the Tiger, Hyæna, and Bear prowled through the woods and inhabited the caverns; and the Horse and Elephant, with gigantic Deer and Oxen, tenanted the plains.

But of MAN and of his works not a vestige appears throughout the vast periods embraced in this review. Yet were any of the existing islands or continents to be engulphed in the depths of the ocean, and loaded with marine detritus, and in future ages be elevated above the waters, covered with consolidated mud and sand, how different would be the characters of those strata from any which have preceded

them! Their most striking features would be the remains of Man, and the productions of human art—the domes of his temples, the columns of his palaces, the arches of his stupendous bridges of iron and stone, the ruins of his towns and cities, and the durable remains of his earthly tenement imbedded in the rocks and strata—these would be the "Medals of Creation" of the *Human Epoch*, and transmit to the remotest periods of time a faithful record of the present condition of the surface of the earth, and of its inhabitants.*

* See Sir H. Davy's Last Days of a Philosopher.

APPENDIX TO PART III.

PROFESSOR OWEN'S CLASSIFICATION OF THE ANIMAL KINGDOM.

(*From the Hunterian Lectures for* 1843.)

Kingdom—ANIMALIA (*animals*).
Sub-kingdom—VERTEBRATA (*having a spinal column*).
Class—MAMMALIA (*animals that give suck*).
AVES (*birds*).
REPTILIA (*reptiles*).
PISCES (*fishes*).

Sub-kingdom—ARTICULATA (*having external-jointed skeletons*).
Class—CRUSTACEA (*having an external crust, or hard skin*).
ARACHNIDA (*spiders*).
INSECTA (*insects*).
ANNELLATA (*composed of rings*).
CIRRIPEDIA (*having curled feet*).

Sub-kingdom—MOLLUSCA (*soft animals*).
Class—CEPHALOPODA (*feet around the head*).
GASTEROPODA (*belly-feet*).
PTEROPODA (*wing-like feet*).
LAMELLIBRANCHIATA (*with lamellated gills*).
PALLIOBRANCHIATA (*mantle-gilled*).
TUNICATA (*enveloped in a cloak*).

Sub-kingdom—RADIATA (*radiated animals*).

NEMATONEURA (*with thread-nerves*). ACRITA (*with indistinct nerves*).

Class—RADIARIA (*rayed animals*).

ECHINODERMATA (*having a spinous skin*). ACALEPHÆ (*with a stinging skin*).

Class—POLYPI (*polypes*).

CILIOBRACHIATA (*with ciliated arms.*) ANTHOZOA (*flower animals*). NUDIBRACHIATA (*with naked arms*).

Class—ENTOZOA (*internal animals*).

CŒLELMINTHA (*hollow worms*). STERELMINTHA (*solid worms*).

Class—INFUSORIA (*infusorial animalcules*).

ROTIFERA (*wheel animalcules*). POLYGASTRICA (*with many digestive sacs*).

PART IV.

NOTES OF EXCURSIONS,

IN ILLUSTRATION OF THE

MODE OF INVESTIGATING GEOLOGICAL PHENOMENA,

AND OF COLLECTING

ORGANIC REMAINS.

GEOLOGICAL EXCURSIONS.

———— "Let the moon
Shine on thee in thy solitary walk;
And let the misty mountain winds be free
To blow against thee; and in after years,
When these wild ecstasies shall be matured
Into a sober pleasure,—when thy mind
Shall be a mansion for all lovely forms,
Thy memory be a dwelling place
For all sweet sounds and harmonies, oh! then
If solitude, or fear, or pain, or grief
Should be thy portion, with what healing thoughts
Of tender joy wilt thou remember me
And these my benedictions!" WORDSWORTH.

I NOW propose to conduct the reader to a few British localities, and point out the mode of examining geological phenomena in the field, and of collecting organic remains from the rocks and strata; in other words, afford a practical illustration of the advantages to be derived from the knowledge acquired by our previous investigations. But from want of space, only one or two excursions can be described in detail; and I must restrict myself in a great measure to extracts from my note-book, and explanatory remarks and suggestions for the guidance of the student and collector. The subjects will be arranged in the following manner:—

1. Instructions for collecting specimens.
2. Excursions illustrative of the geological character and organic remains of the Tertiary deposits of the London and Hampshire basins; namely, to the Isle of Sheppey, Bracklesham Bay, &c.
3. Notes for a geological Excursion over the Chalk and Wealden

districts of the South-east of England; from London, by Tilgate Forest, to Brighton. Also, from Brighton to Rottingdean.

4. Geological notes of various places on the line of the Great Western Railway, from London to Clifton.

5. Excursion to Matlock and its vicinity; to examine the nature and position of the mountain limestone and associated strata of that part of Derbyshire.

6. Geological Notes for an examination of the central group of the plutonic or igneous rocks of England, and of the Carboniferous and Slate strata through which they are protruded: in an Excursion to Charnwood Forest, by Leicester, Mount Sorel, Swithland, Woodhouse, &c. to Whitwick.

CHAPTER XX.

GENERAL INSTRUCTIONS FOR THE COLLECTION OF SPECIMENS.

> "And some rin up hill and down dale, knapping the chucky stones to pieces wi' hammers like sae many road-makers run daft—they say 'tis to see how the world was made."
>
> St. Ronan's Well.

Before we proceed on a geological excursion, it is necessary to be provided with suitable instruments to detach specimens from the rocks, and extract fossils from the strata in which we may find them imbedded, and with materials for packing up our treasures, and noting their localities on the spot. For this purpose, the following articles will be found more or less requisite, according to the particular object of the collector :—

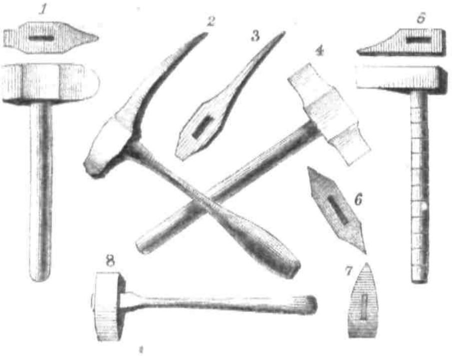
1. A hammer of one of the forms figured in *Lign.* 266. Fig. 3 will be found most generally useful.

2. A leather or strong camlet bag, and one or two of smaller size; the former with strings, or with a strap for the shoulder. If travelling in a carriage, a box or basket may also be provided.

3. Stout and thin paper, and some of a soft kind, for wrapping up specimens.

4. Chip boxes, and raw cotton, wadding, or tow, for the same purpose.

5. String, sealing-wax, and writing paper gummed on one side, for labels to affix to specimens on the spot.



LIGN. 266. GEOLOGICAL AND MINERALOGICAL HAMMERS.

Fig. 1 and 4, 6, are adapted for breaking large stones or masses of hard rock; the thinner ends are convenient for splitting and trimming fragments to a moderate size. The head should be from four to five inches long, one and a half inch wide on the crown, and from two to three pounds in weight; the length of the handle from eighteen to twenty inches.

2 and 3.—This is my favourite hammer, and will be found most generally useful; the short square head for breaking, and the pick for splitting stones, and extracting fossils of moderate size; weight of the head two pounds, length seven inches; width of the crown one and a half inch; handle from twelve to fourteen inches long, and one inch wide at the lower part, for the convenience of a firm hold. If the handle be graduated as a foot measure, as in fig. 5, it will be found useful.*

5 and 8, 7, are smaller hammers for breaking and chipping stones and minerals; the heads from three to four inches long, and one and a half pound in weight; the handle one foot long.

6. A strong pair of gloves, and a pair of eye preservers; common spectacle frames covered with fine black crape will be more agreeable than glass.

* Hammers of this kind may be obtained at Messrs. Knight's, Foster-lane, London; and at 49, Cockspur-street, Charing Cross: care should be taken that the heads are of well-tempered steel, and the handles of tough wood.

7. A measuring tape, a pocket compass, and drawing materials will be required, if the observer intend to note the geological characters of the district.*

8. A good geological map of the country; if this cannot be procured, the best geographical map.

9. A strong double-bladed knife; one or more chisels.

10. A pocket set of single lenses of three powers, to examine minute objects; blank memorandum books.

Such are the articles that will be required for a geological excursion intended to comprehend a scientific examination of a district; but for a mere trip to collect fossil remains, several may be dispensed with. Some years since, an eminent geologist, Dr. Fitton, drew up some excellent instructions for collecting specimens, for the use of the party employed under Captain King to survey the Western coast of Australia; by permission of the author, they are here subjoined.†

INSTRUCTIONS FOR COLLECTING GEOLOGICAL SPECIMENS.

"It may be proper to premise, that two of the principal objects of geological inquiry are, to determine—1st, the nature of the *materials* of which the earth is composed: and, 2dly, the relative *order* in which these materials are disposed in relation to each other.

"1. Specimens of rocks ought not, in general, to be taken from loose pieces, but from large masses in their native place, or which have recently fallen from their natural situation.

"2. The specimens should consist of the stone unchanged by exposure to the elements, which sometimes alter the characters to a considerable depth from the surface. Petrifactions, however, are often best distinguishable in masses somewhat decomposed; and are thus even rendered visible in many cases where no trace of any organized body can be discerned in the recent fracture.

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* On the construction of geological maps and sections, see the Appendix to De la Beche's *Geological Observer*.

† For the collection of rock specimens, and for the mode of observing the phenomena of physical geology, Sir H. De la Beche's instructive volume, "*How to Observe*," should be consulted.

"3. The specimens ought not to be very small;—about three inches square, and three quarters of an inch in thickness, is a convenient size.

"4. It seldom happens that large masses, even of the same kind of rock, are uniform throughout any considerable space; so that the general character is ascertained by geologists, who examine rocks in their native places, from the average of an extensive surface. A collection ought, therefore, to embrace specimens of the most characteristic varieties; and *the most splendid examples are, in general, not the most instructive.* Where several specimens are taken from the same place, a series of numbers should be added to the note of their locality.

"5. One of the most advantageous situations for obtaining specimens and examining the relations of rocks is in the sections afforded by cliffs on the sea-shore; especially after recent falls of large masses. It commonly happens that the beds thus exposed are more or less inclined; and in this case, if any of them be inaccessible at a particular point, the decline of the strata will frequently enable the collector to supply himself with the required specimens, within a short distance.

"6. To examine the *interior* of an unknown country, more skill and practice are required; the rocks being generally concealed by the soil, accumulations of sand, gravel, &c., and by the vegetation of the surface. But the strata are commonly disclosed in the sides of ravines,—in the beds of rivers and mountain-streams; and these, especially where they cross the direction of the strata, may be found, by careful examination, to afford instructive sections.

"The mud and gravel in the beds of rivers and in deltas often contain grains of *gold*, *platina*, and other native metals, rubies, sapphires, and other precious stones; and a general knowledge of the rocks of an unexplored country often may be gained from the detritus at the embouchure of a river.

"7. Among the contents of the strata, the remains of organized bodies,—shells, corals and other zoophytes,—the bones and teeth of animals,—wood, and the impressions of vegetable stems, roots, or leaves, &c. are of the greatest importance; affording generally the most marked characters of the beds in which they occur. These should, therefore, be particularly sought after, and their relative abundance or rarity in different situations noticed. The fossiis should, if possible, be kept united with portions of the rock or matrix in which they are found; and where they are numerous,—in sand, clay, or any moist or friable matrix,—it is, in general, better to

retain a large portion of the whole mass, to be examined afterwards, than to attempt their separation at the time of collecting.

"8. The *loose substances* which are found above the solid rocks, in the form of gravel, silt, rolled pebbles, &c., should be carefully distinguished from the *solid strata* upon which they rest. And the more ancient of these water-worn materials, found on the sides or summits of hills, &c., should be distinguished from the recent mud, sand, and gravel, brought down by land-floods or by rivers. The bones and teeth of quadrupeds are not unfrequently found in the more ancient gravel; and the collection of these remains from distant quarters of the globe is an object of the greatest interest to geology.

"9. Besides a note of the locality, there ought, if possible, to accompany every specimen a short notice of its geological circumstances; as, for example, whether it be found in large shapeless masses, or in strata? If in strata,—what are the thickness, inclination to the horizon, and direction with respect to the compass, of the beds? If these cannot be measured, an *estimate* should always be recorded while the objects are in view. Are they uniform in dip and direction?—curved, or contorted?—continuous, or interrupted by fissures or veins? Is the whole cliff, or mass of strata in sight, of uniform composition?—or does it consist of different kinds of stone? If the strata be different, what is the order in which they are placed above each other successively?

"10. A *label*, distinctly written, should accompany every specimen, stating its native place, its relative situation, &c., and these labels should be attached to the specimens immediately, on the spot where they were found. This injunction may appear to be superfluous; but so much valuable information has been lost to geology from the neglect of it, that every observer of experience will acknowledge its necessity. It is useful to mark on the labels the day, and even the hour, when each specimen is collected. This, with a corresponding note in the memorandum-book, prevents confusion, and will be found to assist the memory.

"11. A *sketch* of a coast or cliff, however slight, frequently conveys more information respecting the disposition and relations of rocks, than a long memorandum. If numbers, denoting the situation of the specimens collected, be marked upon such sketches, much time may be saved at the moment of collecting. But in all such cases, the memorandum should be looked over soon afterwards, and labels, distinctly explaining their situation, &c. be attached to the specimens.

"12. The specimens should be so packed, that the surfaces may

be defended from exposure to air, moisture, and friction: for which purpose, if strong paper cannot be obtained, dry moss, or straw, or leaves may be employed. Where paper is used for wrapping the specimens, they are best secured by fastening the envelope with sealing-wax.

"Lastly. The collector must not be discouraged, nor be prevented from collecting, by finding that the place which he may chance to visit in a remote situation has not a striking appearance, or the rocks within his view a very interesting character; *since it frequently, and even commonly happens, that facts and specimens, in themselves of very little importance, become valuable by subsequent comparison; so that scarcely any observation, if recorded with accuracy, will be thrown away.*"

These general instructions will suffice to prepare the reader for an excursion to some known locality, where his researches will certainly be rewarded by many interesting organic remains; and he may be so fortunate as to meet with some rare fossils, and perhaps with one or two that have not previously been discovered; for there is always a chance of finding relics hitherto unknown, even in a cliff or quarry that is daily visited by collectors. And as an old sportsman desirous of inspiring a novice with a love of field sports, takes him at first to preserves where game is plentiful, in like manner I would initiate my reader in the delightful pursuit of collecting *Medals of Creation*, by conducting him to a spot where these antiquities of nature are scattered about in great profusion and variety.

CHAPTER XXI.

EXCURSIONS ILLUSTRATIVE OF THE GEOLOGICAL CHARACTERS AND ORGANIC REMAINS OF THE TERTIARY DEPOSITS OF THE LONDON BASIN.

In leaving London for any part of England, the reader will remember that the area on which the metropolis is situated, as well as the surrounding district to a distance varying from a radius of ten to twenty or thirty miles, consists of the marine Tertiary *eocene* strata (see p. 24), which have been deposited in, and still occupy, a depression, or excavation of the Chalk, called the *London Basin* (*Wond.* p. 229). Around this formation, the Chalk forms a distinct boundary on the south, west, and north, rising up into chains of hills or downs; but on the east the range is broken, and the Tertiary basin lies open to the sea, affording a passage for the Thames and its tributary streams. From this geological character of the metropolitan district, it results, that all the lines of railroad proceeding from London traverse, for the first ten or twenty miles, beds of clay, loam, and loosely aggregated sand and gravel; hence the numerous slips that have taken place in the embankments; as for example, at New Cross, Wandsworth Common, near Hanwell, &c.; and in all these lines it is obvious, from the nature of the strata and the steepness of many of the cuttings, that similar catastrophes will again occur.

The next geological feature observable in the lines of all the London railroads is the Chalk, which is invariably passed either by steep cuttings, or tunnels, or both; as for

example, from near Croydon to Merstham, by the South-Eastern; from near Basingstoke to beyond Winchester, by the South-Western; from Maidenhead to beyond Wallingford, by the Great Western; and from beyond Watford to near Ivinghoe, by the Birmingham line.

After passing through the Chalk, and over the marls and sandstone strata of the Cretaceous formation, the Oolitic group (consisting of Portland stone, Kimmeridge clay, &c.), the Lias, New Red or Triassic, and Carboniferous deposits successively appear on the lines of railroad; excepting on those of the South-Eastern, which, upon leaving the Chalk formation, traverse the fluviatile beds of the Wealden, as we shall hereafter more particularly describe.

EXCURSION TO THE ISLE OF SHEPPEY.

Every one knows that Sheppey is a small island about ten miles in length, lying at the mouth of the Thames, at the distance of between forty and fifty miles east from London; but every one does not know that the Isle of Sheppey is an inexhaustible mine of fossil treasures; and that from its cliffs, and on its shores, may be gathered innumerable relics of tropical plants, of quadrupeds, birds, serpents, turtles, fishes, crabs, lobsters, shells, &c. all belonging to species that now no longer exist.

A visit to the town of Queenborough afforded me, when a boy, the first opportunity of beholding fossil remains in such a state of preservation, and in such profusion, as to excite in my mind an uncontrollable desire to investigate the nature and origin of objects which I had been taught to believe were either produced spontaneously in the earth, or were left in their present situations by the waters of a universal deluge. At a short distance from the inn where we

sojourned, was a vitriol manufactory, and considerable plots of ground were covered with the pyritous clay, obtained from the neighbourhood. To my great astonishment, I perceived that masses of this fossil earth were almost wholly made up of stems, twigs, and fragments of wood, with innumerable fruits, seed-vessels, and berries, of kinds altogether unknown to me. These fossils were of a dark colour, some quite black, very heavy, and permeated with the mineral substance termed sulphuret of iron, or pyrites. Many were so brittle as to fall to pieces upon being handled, but others were of a stony hardness, and I quickly filled a handkerchief with my newly discovered treasures, and hastened home to examine them at leisure. They consisted of the usual kinds of fossil fruits so abundant in the island (see *Lign.* 63 and 64, p. 188), with casts of shells, and a few claws of crabs, and teeth of fishes.

Most of the specimens fell to pieces in the course of three or four months, but a few were durable, and these still occupy a corner in my cabinet as precious mementos of my juvenile researches. Many years afterwards I revisited Sheppey, and made a large collection of its fossils, which is now in the British Museum. Of late years, the increasing taste for Palæontology has brought numerous visitors to the island, which steam navigation has now placed within a few hours' distance of the metropolis; and the demand for choice fossils has given rise to several local dealers. The student may, with but little trouble or expense, visit the island, make himself familiar with its geological character, and return laden with the fruits of the ancient spice islands, of whose ruins this mass of clay, in the embouchure of the Thames, is almost wholly composed. As it is some years since I last visited this interesting spot, I have obtained, as a Cicerone for the reader, the most indefatigable and successful investigator of its fossil Flora, MR. BOWERBANK; and as the courtesy of this gentleman is equal to his

intelligence and scientific attainments, the traveller will have no reason to regret the absence of the author. A trip from London to Sheppey and back, affording time to procure a good collection of fossils, may be easily accomplished in three days.

EXCURSION TO THE ISLE OF SHEPPEY, BY J. S. BOWERBANK, ESQ. F.R.S.*

"The best conveyance is by the Southend and Sheerness steam-packets, which leave London-bridge on Tuesdays, Thursdays, and Saturdays, at 11 o'clock in the morning, and reach Sheerness about 4 or 5 o'clock in the afternoon. The town is divided into two parts,—the one contained within the limits of the garrison being designated the Blue town, while that beyond the fortifications to the north-east is designated the Mile-town; and it is to this portion that I should recommend the visitor to proceed, and take up his quarters either at the Royal Hotel, or at the Wellington: the latter is an exceedingly snug and comfortable house, to which I have resorted for many years. After having established himself in the inn, he should request the attendance of Mr. Hays (better known perhaps by the name of *Paddy Hays*), from whom he may purchase, at a reasonable rate, some good fossils, such as crabs, lobsters, heads and portions of fishes, and numerous species of fossil fruits. Our traveller will then have accomplished all that can be done towards the acquisition of fossils until the following morning; there not being, I believe, any other collector in the town from whom purchases can be made.

"On the following morning an early breakfast is desirable,

* Abridged from the Annals of Philosophy, by permission of the author.

as a considerable extent of ground is to be traversed. It is advisable to go provided with five or six sheets of soft paper, to wrap fragile specimens in; and a few cotton or linen bags, of about four or five inches in diameter, to separate the large from the small fossils; the whole to be carried in a good-sized blue bag, or haversack; a chisel and light hammer are the only instruments required. If the geologist has a desire to view the great section of the London Clay, afforded by the cliffs on the north shore of Sheppey, and is content with the comparatively few fossils which he may be able to procure by his own exertions, he may proceed in the following manner:—Leaving Sheerness by the new town, he will pass along the sea-wall, towards Minster, until he reaches Scaps-gate, where the cliffs begin to rise from the low lands of the western end of Sheppey. A few cottages are scattered round this point, some of the inhabitants of which work upon the beach, collecting either cement-stone or *pyrites*, the latter being better known by the name of *copperas*. To these application should be made for 'curiosities,' and very frequently excellent specimens, and at a small price, may be thus procured. From this point the route will be under the cliffs upon the shingle, amidst which, dark patches, ten or fifteen yards in length, will be observed, composed of nodules of *pyrites*, intermixed with pyritized fragments of branches of trees, in great abundance. It is at such spots that the numerous and beautiful specimens of fossil fruits are found; but, to ensure success, the collector must be content to go upon his knees, and carefully search among the fragments. The whole of the beach, from about the parallel of Minster church to Warden Point, abounds with these patches of *pyrites;* and I have by this means obtained in the course of a morning upwards of one hundred fine fruits of various sizes. Care must be taken in such an investigation of the coast, that it be undertaken *during the falling of the tide,*

or unpleasant consequences may arise from being shut in between the banks of mud which are projected into the sea at many points of the coast.

"If the principal object be the attainment of the greatest quantity of fossils, a different course should be pursued. The collector should then, after having made his purchases at Scaps-gate, direct his steps towards Minster church, passing which, he will proceed on the road towards Warden. About three-quarters of a mile beyond the church there is a lane on the left hand, leading towards the Royal Oak, in which lives a woman named Mummery, and several others, who work upon the beach, and from whom fossils are frequently to be procured. These people will direct him to the cottage of a family named Crockford, who have usually a good assortment of fossils; and to many other parties who also work upon the beach, and reside between this point and Hensbrook, to which place he must now direct his steps. At Hensbrook inquiry should be made for a man named Pead, who has generally a considerable number of good specimens in his possession. From this point (Hensbrook) the collector must proceed along the top of the cliff towards Warden, calling at the various cottages in his way, until he arrives at Warden Point, at which place he must inquire for Mud-row, many of the inhabitants of which work upon the beach, and from whom a considerable addition to the specimens already collected may be purchased. Beyond this point nothing will be obtained, and the best way to return to Sheerness, is by the road which runs through the most level portion of the country; the path along the north cliff undulates very considerably more than the road.

"The course of proceeding thus sketched applies to the supposition that the time is limited to three days, but if a longer period can be spared, I should recommend the tourist not to leave Sheerness without viewing the dock-

yard; and the return to London may be made by the way of Chatham and Gravesend, affording the gratification of a view of the dock-yard and lines at Chatham, and of the fine old cathedral and castle at Rochester; at the same time, enabling him to arrive in London on the evening of the day that he quits Sheerness."

If the student's time will permit, a day or two may be profitably spent at Herne Bay on his return; and search should be made for fossils under Swale Cliff and Studd Hill, where numerous fruits and some unique mammalian remains have been found by William Richardson, Esq. (see p. 791). Should he land at Gravesend, as recommended by Mr. Bowerbank, he should proceed towards the lime-kilns which lie on the London side of the pier, on the right bank of the Thames. To the left of the limekilns he will perceive a road leading by some bold chalk cliffs to the high ground above Gravesend; and on the right hand there is a row of cottages, or rather huts, inhabited by the labourers that work in the quarries and kilns. Many of the usual fossils of the Kentish Chalk may be obtained of the women or children in these huts; and sometimes *Cidares*, or turban Echinites (p. 314), with spines; and Star-fish (p. 306). A visit to the chalk-pits at Purfleet, on the opposite side of the river, is very desirable; many interesting fossils having been found in that locality. The Kentish Chalk in this district is much softer than that of Sussex, and the fossils may be easily cleared with a penknife, or by brushing in water; care should be taken not to wash them roughly, as they will readily separate from the chalk.

The fossils procured from the Isle of Sheppey, by such an excursion, will probably consist of portions of stems and branches of trees, and fragments of wood, perforated by Teredines (see p. 193); specimens of the fruits of palms, resembling the recent *Nipas* of the Moluccas (p. 188), and of plants allied to the Cucumber, Bean, Cypress, Laburnum,

&c. (p. 189); claws and fragments of the shields of Crabs (p. 512); bones of Crocodiles, Serpents, and Turtles; bones and teeth of Sharks (p. 591); Rays (p. 598), and other fishes; and several species of the usual shells of the London Clay (p. 383), and a specimen or two of Nautilus (p. 469).

NOTES FOR AN EXCURSION TO BRACKLESHAM BAY, ON THE WESTERN COAST OF SUSSEX.

The line of low cliffs extending from Selsea Bill to the mouth of Chichester Harbour exhibits a section of the Eocene deposits, varying in height from five or six feet to ten or twelve; it is covered at its base by a bed of shingle, fifteen or twenty yards wide, that extends towards the sea. The space between the termination of the shingle and the limit of low-water-mark is occupied by a bed of dark grey and greenish sand; and at certain seasons, numberless specimens of the fossil shells common in the Eocene strata of the London and Paris basins are thickly spread over this area.

Mr. Webster first directed attention to this locality, in his celebrated Memoir on the Tertiary Strata of England; and my friend, the late John Hawkins, Esq. of Bignor Park, followed up the inquiry. In 1821 I made a fine collection of the Bracklesham fossils, and published a list of them in *Foss. South D.* and *Geol. S. E.* Messrs. Bowerbank, Saull, Dixon, Coombe, &c. have subsequently made considerable and important additions to the catalogue; and besides many new species of shells, the vertebræ and other bones of Turtles, Serpents, and Crocodiles have been discovered. An excellent notice of this locality, from the pen of Mr. Bowerbank, appeared in *Mag. Nat. Hist* (1840); and I am indebted to the kindness of the author for the following notes for the guidance of my readers.

"The part of the bay most interesting to the geologist is that immediately in the neighbourhood of Bracklesham Barn, especially at about a furlong to the east of that spot, where there is a small break or chine in the low clay cliff. At this place, and at a few paces east and west of it, beneath about six or seven feet of clay, there is a stratum of light green marly sand, abounding in remains of *Venericardia planicosta* and other shells, but which is often entirely hidden by thrown-up shingle, and it is very rarely that more than a few feet in length of this bed can be seen. It is from this bed, or from one exceedingly like it, somewhat lower in the series, that perhaps most of the interesting shells of this district are to be procured. If we proceed from this little break or chine westward, for about forty paces parallel to the coast, and then in the direction of a line at right angles to the cliff, and at the time of low water, we shall find, near the low-water-mark, the bed we have described as abounding in fossils exposed by the action of the sea in the most favourable manner. At this spot *Venericardia planicosta* is found literally by thousands, with the valves united, the shells resting upon their edges, and packed close to each other, exactly in the manner that we might expect to have found them, supposing them to have been recent shells with the animals yet inhabiting them. Comparatively very few are gaping, and their condition and position strikingly impress upon the mind the idea that when alive they must have inhabited the spot from which they are now disinterred; especially as there are numerous small and fragile species of other well-known London Clay shells, which could not have remained whole had they been subjected to much attrition amid the larger shells surrounding them. On the sands in the vicinity of this spot, I found large masses of *Nummulites lævigatus* cemented together, and numerous detached specimens of the same shell.

"At the eastern extremity of this bed, which, at the time of my visit, was opened for about fifty yards, I found *Sanguinolaria Hollowasii*, a rare and fragile, but very beautiful shell, in a fine state of preservation. At about twenty or thirty yards westward of the western end of this interesting patch of shells, there are large blocks of this bed, which, being of a firmer texture than the surrounding parts of the deposit, have suffered less from the action of the water, and project about twelve or eighteen inches above the surrounding sand, and, by presenting an obstruction to the ebbing tide, they usually induce the formation of a small pool amidst which they stand. At the south-eastern side of this pool on one occasion I found the stratum, which is usually covered by the sand, completely

exposed. At this spot there was scarcely a specimen of *Venericardia planicosta* to be seen, but instead of this shell, *Turritella conoidea* and *T. edita* were imbedded in a dark green marly sand; and among them, together with *Fusus longævus* and other well-known London Clay shells, I found *Venericardia acuticostata* and *V. mitis*, and a splendid specimen of *Conus deperditus*, fully equal in size to the one figured by Deshayes. Westward of this point I did not meet with anything particularly interesting.

"About midway between Bracklesham Barn and the Thorny coast-guard station, a series of patches of a deposit of chalk-flints was exposed; the first of these was nearly at low-water-mark, and the remainder of them ran, at short distances from each other, in a diagonal line towards the coast, nearly in the direction of a straight line drawn from their western extremity to the Thorney station-houses. Apparently, this stratum of flints has not, at any time, exceeded eight inches or a foot in thickness; they are, indeed, so thinly scattered, as rarely to occur piled upon each other: very few of them have suffered from attrition, and the greater part retain their original form and whitened surface. They are imbedded in the same light green marly sand which I before described as occurring at the bottom of the London Clay in the neighbourhood of the little chine near Bracklesham Barn. Amongst the flints there are numerous remains of the roots of trees, in the state of soft bog-wood; which indicate that this portion of the strata has been very thinly covered by the superimposed clay.

"Upon one of the bouldered flints, firmly imbedded in the marly sand, I found the most interesting of the valuable series of fossils which I had the good fortune to obtain during this excursion, namely, a fine specimen of *Astræa* * attached to the upper and exposed surface of a flint."

As to the accommodation that may be procured near this interesting geological locality, Mr. Bowerbank informs me that homely fare can be obtained at the little inn at Bracklesham, but there is only one spare bed. At Selsea, about six miles distant, there is a much better inn.

* *Astræa*, a species of coral; see p. 262.

NOTES FOR AN EXCURSION TO THE TERTIARY STRATA OF THE ISLE OF WIGHT.

[See Geological Excursions round the Isle of Wight, and along the adjacent Coasts of Dorsetshire, by the Author. 8vo. 3d edit. With Prefatory Note by T. Rupert Jones. 1854. Bohn. London.]

Land at Cowes; examine the blocks of fresh-water limestone along the shore, which abound in shells. Drive to Alum Bay (*Wond.* p. 241), taking Calbourn in your route, where there are quarries of the fresh-water limestone, with innumerable casts of Paludina, Helix, Bulimus, &c. Put up at Groves' Hotel, on the summit of the hill, commanding a glorious view of Alum Bay, with the Hampshire coast, and the Isle of Purbeck on the right, and Portland Island looming in the remote distance; and on the left, the vertical cliffs of Chalk, and the Needles. The pathway that leads down to the sea-shore traverses a chasm, separating Headon-hill on the right, from Alum Bay on the left; in the former, fresh-water shells—in the vertical beds of clay, in the latter, marine shells—may be obtained in great abundance and variety.

If you land at Ryde, the small quarries at Binstead are worthy of constant research, for the chance of mammalian remains (see p. 791).

The following extract from the splendid work of Sir Henry Englefield on the Isle of Wight describes certain geological changes still in progress on the shore near Ryde, that are well deserving the visitor's attention.

"A great and very singular change has taken place within no very distant period of time on the shores of the Solent, near to Ryde; and which seems to be still sensibly proceeding. When Fielding, in the year 1753, was at Ryde, on his voyage to Lisbon, he describes the town as totally inaccessible by sea except at or near high-water; as the tide, on its recess, left a vast extent of mud, too soft to bear the lightest weight. This mud-bank is now entirely covered by a

stratum of fine white sand, smooth and firm enough to bear wheel-carriages, and which renders the bathing at all times safe and agreeable. This bed of sand now reaches to Binstead, having covered at least two miles of the shore within the last half-century; and the inhabitants say that it is still extending to the westward. On digging through the sand, the old mud presently appears, the sand stratum being very thin. To what cause this change is owing it is difficult to guess; but it is an example of the alternation of deposits from the action of the sea, in circumstances apparently unchanged, which may afford cause for reflection to the geologist." *

If the visitor have leisure, he should make a tour of this interesting island, from Ryde to Shanklin and Ventnor, along the beautiful scenery of the Under Cliff, formed by the slips of the Lower Green Sand; to Black Gang Chine, and Fresh-water Bay; visiting Brook Point (*Wond.* p. 378) to collect fossils from the Wealden strata on the sea-shore.

* Sir H. Englefield's Isle of Wight, p. 16.

CHAPTER XXII.

NOTES FOR A GEOLOGICAL EXCURSION, OVER THE CHALK AND WEALDEN FORMATIONS OF THE SOUTH-EAST OF ENGLAND, FROM LONDON TO BRIGHTON, AND FROM BRIGHTON TO ROTTINGDEAN.

In travelling from London to Brighton by the railway, the following geological features of the country may be observed; by a reference to *Wond.* p. 360, the structure of this remarkable district may be easily understood.

Leaving the station at London Bridge, the *London Clay*, with its characteristic fossils, is seen beyond Deptford, by New Cross, Sydenham, &c.; and approaching Croydon, beds of gravel appear, with interspersions of olive-green sand. These strata belong to the Eocene formation, and lie above and upon the Chalk. The valley beyond Croydon (Smitham Bottom), along the side of which the railroad is carried, is composed of gravel resting on chalk; beyond the station called *Stoat's Nest*, there is a fine section of the chalk, with layers of flint, and two parallel seams of marl, at the distance of six or eight feet from each other. These extend, with but little interruption, several miles, preserving their parallelism, although the strata in many places have sustained considerable disturbance. The Merstham Tunnel, through the Surrey chalk hills, is now entered. At Merstham the chalk, chalk-marl, and firestone are intersected, and the Lower Greensand of Red Hill appears; and from thence to Horley station, the lower sands and clays of the Chalk formation are passed over or cut through; affording sections of sandstone, ironstone, and fuller's earth.

The strata we have hitherto traversed are of marine origin, and contain fossil shells, fishes, crustacea, &c., and remains of other inhabitants of former oceans. But we now enter upon the series of river deposits * which form the Wealden, and contain the relics of terrestrial or fresh-water animals and plants.

At Horley the weald clay appears, and is succeeded by sand, sandstone, and shale, to Crawley. Passing through the tunnel of the Wealden strata, we arrive at Balcombe, where sandstone in laminæ and in thick beds, having the surface at the lines of junction covered with ripple marks, is seen on each side the railroad; the dip of the strata is to the *north-east*. After crossing the deep valley at Balcombe, over the magnificent viaduct, the line runs along alternations of sand and clay, dipping *south-west*; we have thus passed over what is termed the anticlinal axis of the Wealden. Arriving at Hayward's Heath station, the tunnel exposes a good section of the Wealden sand, sandstone, shale, and blue marl or oak-tree clay, to a depth of about thirty-six yards. The strata are disposed in the same order and thickness as in the quarries around Cuckfield; namely, fawn-coloured sand and sandstone, like those of Little Horsted, with beds of calciferous grit or Tilgate stone; and, beneath, layers of the blue clay. The strata are very barren in organic remains; several hours' research only afforded imperfect vegetable relics, such as comminuted stems and leaves of the various species of ferns, which occur in Tilgate Forest (see *Wond.* p. 392). Some of the grey laminated sandstones and shales at this place very closely resemble certain strata of the Coal measures.

Proceeding over the Weald clay with the Sussex marble of St. John's Common, the line encounters the Lower Green-

* A limited intercalation of a marine character occurs in the Hasting Sands of Swanage Bay; this was discovered by Mr. R. A. C. Austen, and is noticed *Quart. Geol. Journ.* vol. vii. p. lix.

sand of Sussex, at Stone-pound gate. Here then we quit the fresh-water strata of the Wealden, and again enter upon the marine deposits of the Chalk formation. At the foot of the northern escarpment of the South downs, the Chalk is penetrated at the base of Clayton Hill, the tunnel running through the lower members of the Chalk—the Galt and Chalk-marl—and emerging at Piecombe through the White Chalk; from thence to Brighton, the sections and tunnels intersect or perforate the same cretaceous deposits.

In our traverse we shall have seen that the various strata cut through, are repeated on the north and south of a line drawn from east to west through the Forest Ridge (see *Wond.* Geol. Map, pl. i.). Thus, the railroad has to pass through two ranges of chalk hills by tunnels—those of Merstham and Clayton; two principal ridges of Wealden strata—at Balcombe and Hayward's Heath; and the Shanklin or Lower Greensand at Red Hill, in Surrey, and near Hurstpierpoint, in Sussex. There is no railroad in the kingdom that, in the distance of fifty miles, exhibits geological phenomena of greater variety or interest.

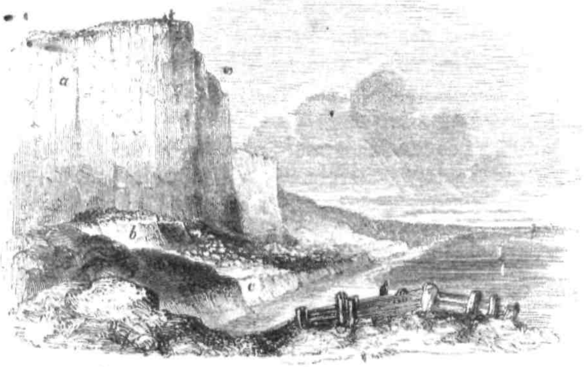
If the student will refer to *Wond.* p. 362, the stratification above pointed out will be better comprehended. The sections visible on the turnpike road from London to Brighton are described, *Wond.* p. 363.

The neighbourhood of Balcombe station will afford some sections of easy access; and from Hayward's Heath station, Cuckfield is about two miles distant. The quarries on the hill above that town were formerly very productive, and the usual Wealden fossils may still be obtained; namely, casts of several species of fresh-water shells (p. 416), scales and teeth of fishes (*Lepidotus*, p. 604), bones of reptiles, and vegetable remains.

GEOLOGICAL STRUCTURE OF BRIGHTON CLIFFS.

"Yes! where the huntsman winds his matin horn,
And the couch'd hare beneath the covert trembles;
Where shepherds tend their flocks, and grows the corn;
Where Fashion on our gay Parade assembles—
Wild Horses, Deer, and Elephants have strayed,
Treading beneath their feet old Ocean's races."

HORACE SMITH.



G. A. M. del[t.] 1836. *J. Whimper, lign[t.]*

LIGN. 267. BRIGHTON CLIFFS, NEAR KEMPTOWN,

From the Sea-shore, looking East, or towards Rottingdean.

a.—The Elephant-bed.
b.—An ancient Sea-beach, composed of shingle and boulders of granite, porphyry, &c.
c.—The Chalk which forms the base of the cliff.

A stroll from Kemptown along the sea-shore to Rottingdean is replete with interest, for the strata of which the cliffs are composed clearly demonstrate that in very remote

periods great changes have taken place in the relative position of the sea and land along the Sussex coast.

Some years since, the bare face of the Cliffs, from the entrance to the esplanade of the Chain-pier at the Old Steyne, to Kemptown, was completely exposed, and presented a most interesting section of the strata. But at the present time, as every one knows, no portion of the cliffs is visible west of the *groin* below Kemptown; and the sections in my first work (*Foss. South D.* pl. iv. and v.) are the only records of the appearances formerly presented, and now concealed by the sea-wall. Even the cliffs immediately beyond Kemptown are rapidly diminishing from the action of the waves, which dash with greater violence against their base in consequence of the means taken to protect the adjoining terraces from the encroachments of the sea.

The appearance of the Cliffs east of Kemptown is shown in the sketch, *Lign.* 267. But further along the shore, towards Rottingdean, in a ravine excavated by the encroachments of the sea, the ancient chalk cliff behind the mass of strata seen above is exposed; this is represented in *Lign.* 268. A description of the appearances at this point will elucidate the nature of the strata of which these cliffs are composed.

Upon examining the shore at low-water, masses of chalk, covered with fuci (*sea-weed*), &c. are seen protruding through the sands; and towards the base of the cliff a bed of sea-beach is spread upon the sand; a low wall or terrace of white chalk constitutes the boundary of this shingle, as seen in *Lign.* 267, *c.* Thus we perceive, that the present shore is formed by the continuation of the chalk strata of the neighbouring Downs, partially covered with sand and beach, which are the detritus of the flints that have been washed out of previously existing layers of chalk, and ground down by the action of the waves. Now, along the eastern part of the coast, towards Rottingdean and Newhaven, the chalk

rises into mural precipices immediately from the sea-shore; but at this place the cliffs are composed of very different materials.*

1. In the first place, there is, lying immediately on the terrace of chalk that forms the boundary-wall of the base of

LIGN. 268. CLIFFS BETWEEN KEMPTOWN AND ROTTINGDEAN: seen from the West.

a.—ELEPHANT-BED; calcareous strata, containing teeth and bones of Elephants.
b.—ANCIENT SHINGLE, or sea-beach.
o.—BED OF SAND; containing bones of Whales, and marine shells.
c, c.—Strata of undisturbed CHALK, dipping towards the Downs.

the cliff (*Lign.* 267, *c*, and *Lign.* 268, *c c*,), a bed of sand (denoted by the letter *o*, *Lign.* 268), of irregular thickness and variable extent: from this sand marine shells and the jaw of a Whale (see p. 778), have been obtained.

2. Upon the sand is a bed of loose shingle—a regular sea-beach—appearing in no respect different, to the common observer, from that forming at the foot of the cliffs at the present moment; this bed is marked *b*, in *Lign.* 267, and

* *Wond.* p. 113; and *Quart. Journ. Geol. Soc.* vol. vii. pp. 365, 396.

268. Upon examining this shingle, it is found to contain numerous pebbles and boulders of granite, porphyry, syenite, and other plutonic rocks (see p. 34), none of which occur in the present beach. And in this ancient shingle, teeth and bones of extinct species of Elephant, Horse, and Deer have been discovered. We have here, then, unquestionable evidence that this beach has been formed under conditions altogether different from those which now prevail; for not only is this shingle-bed elevated above the present sea-level, but its contents are of such a nature as could not have been thrown up by the sea, in its present relation to the countries that form its shores.

3. A series of loosely aggregated calcareous deposits, obscurely stratified, rests upon this bed of shingle, and forms the upper portion of the cliff, varying in total thickness from fifty to one hundred and twenty feet. These strata are composed of chalk rubble and loam, with flints partially water-worn, and boulders and pebbles of tertiary sandstone; the whole promiscuously intermingled, and deposited in nearly horizontal layers, from one to three or four feet thick. But the face of the cliff generally presents a weather-worn and crumbling aspect, and large masses are constantly falling down, in consequence of the removal of the ancient shingle, by the effects of the waves at the spring-tides. From the loose state of aggregation of these beds, the fallen masses are speedily washed away, but here and there blocks of great hardness, provincially termed *Coombe-rock*, remain upon the shore; and, but a few years since, there was a group of high rocks of this kind near the Chain-pier. This compact conglomerate has been produced simply by an infiltration of calcareous spar, which has cemented together the fragments of chalk, flint, &c. In some places, this infiltration has reached the bed of ancient shingle below, and large blocks are occasionally found, consisting of pebbles of flint, granite, &c. held together by veins of calc-spar, in

acicular or needle-like crystals. In these sparry conglomerates, the teeth and bones of the mammalia previously noticed are sometimes found.*

It is in this accumulation of calcareous strata that numerous bones and teeth of the Mammoth, or fossil Elephant, have been discovered; I have therefore designated it, the *Elephant-bed*, to distinguish it from other loose calcareous deposits.

As seen immediately beyond Kemptown (*Lign.* 267), the cliffs appear to be entirely composed of the materials above described; but farther on, the face of the ancient chalk-cliff is exposed (see *Lign.* 268); and if we extend our walk to Rottingdean, we find in many places the Chalk alone forming the present cliff; the Elephant-bed and its associated shingle and sand having been swept away. A like destruction awaits the remainder of these interesting deposits at no very distant period.†

After collecting specimens of the Elephant-bed, both of the friable varieties, and of the coombe-rock, and a few of the pebbles of granite, porphyry, &c. from the ancient beach, and also some of the sand beneath the shingle, to examine microscopically on our return home, let us sit down on this mass of fallen chalk, and consider the nature of those changes in the relative position of the land and sea, which the phenomena before us appear to indicate.

We have seen that these cliffs are composed of the following deposits:—1. The Elephant-bed (*Lign.* 267 and 268, *a*); a series of calcareous strata, with bones and teeth of Elephants, Horses, Deer, and Oxen. 2. An ancient sea-beach (*b*), with pebbles and boulders of plutonic rocks, and

* My daughter discovered part of the lower jaw of a Deer, with teeth, imbedded in this conglomerate, in a mass on the shore near Rottingdean.

† See *Foss. South D.* p. 277, pl. iv.; and *Geol. S. E.* p. 30; *Wond.* p. 113

bones of mammalia ; and a bed of sand beneath, in which cetacea and mollusca (apparently of existing species) have been found. 3. Lastly, the regular Chalk-strata (*Lign.* 268, *c, c*), extending far out to sea.

These appearances demonstrate the following sequence of physical changes, namely—

1stly. The Chalk terrace (*c, c*), on which the ancient shingle-bed (*b*) rests, was on a level with the sea for a long period ; for this beach must have been formed, like the modern, by the action of the waves on the then existing chalk cliffs (see *Lign.* 268, *Chalk*). But there must have been some cause in operation, by which pebbles and boulders of granite, porphyry, and other rocks, foreign to our shores, and bones of Elephants, &c. were thrown up on the strand, and imbedded in the beach then in the progress of formation. These transported materials may have been floated to the Sussex coast by icebergs ; an agency by which the delicate bones and teeth might be deposited without injury, although surrounded by the water-worn detritus (see p. 43).

2dly. The whole line of coast, with the ancient shingle, must have subsided to such a depth, as to have allowed of the deposition of the calcareous strata, forming the Elephant-bed. And from the absence of gravel and beach, and the circumstance of the chalk-rubble, of which they are largely composed, often presenting angular fragments, it would appear that this deposition took place in some tranquil bay or inland sea.

Lastly. The land was elevated to its present level ; and at this period the formation of the existing sea-beach and line of cliffs commenced.

The reader must not conclude, from our remarks being restricted to the cliffs before us, that the phenomena here contemplated were limited to this district ; on the contrary, if our space would permit, it might be shown that they are referable to extensive geological changes, which took place

in the period immediately antecedent to the present. In all the valleys of the South-east and East of England that open into the sea, traces, more or less extensive and important, of similar deposits exist. The level plain, called the *Steyne*, at Brighton, is entirely formed of the Elephant-bed, which extends up the valley to Preston and Patcham; in the latter place bones and teeth of Elephants have been found. At Southbourn, the plain at the foot of the Chalk hills, called "*The Wish*," containing remains of the Elephant, Rhinoceros, and Hippopotamus, evidently belongs to the same epoch. At Folkstone, Mr. H. Carr has discovered large blocks of *Coombe rock*, and Mr. S. J. Mackie abundance of bones; and at Dover, above the Chalk, similar masses occur. On the opposite coast of France there are also indications of these deposits. All these phenomena are no doubt connected with the occurrence of immense quantities of mammalian remains in the superficial loam, &c. on the eastern coasts of England, and are referable to the same geological epoch.

Imbedded in the Chalk, which is exposed at low water along the shore, very large Ammonites may sometimes be found between Kemptown and Rottingdean; and numerous examples of fossil sponges and other amorphozoa (p. 219).

The teeth and bones of mammalia are rare in these cliffs, and it is not probable that any will be obtained in a first visit; but from the fishermen and boys seen strolling along the shore, specimens may often be purchased.

CHAPTER XXIII.

GEOLOGICAL NOTES OF VARIOUS PLACES ON THE LINE OF THE GREAT WESTERN RAILROAD, FROM LONDON TO CLIFTON.

THAT splendid railway, the Great Western, by which the geologist may be transported in five or six hours from the Tertiary strata of the metropolis to the magnificent cliffs of Mountain limestone at Clifton, exposes in its course several fine sections, and passes within a moderate distance of some interesting localities of organic remains.

This railroad traverses the *Tertiary* strata by Ealing, Hanwell, and Slough, entering the *Chalk* near Maidenhead, and pursuing rather a circuitous route to Wallingford, beyond which station it passes over the *Oolite*, and displays some bold sections of the limestones and clays of that formation. Near Bath it emerges on the *Lias*, and crossing a narrow belt of the *New Red*, passes on to the *Carboniferous* strata of the Bristol coal measures.* In this route, there are four places particularly deserving a visit from the geological student, and collector of organic remains, namely, Farringdon, Swindon, Calne, and Chippenham.

VISIT TO FARRINGDON.—The railway station is reached in from two to two and a half hours from London; and an omnibus meets the morning and evening trains, to convey passengers to the town of Farringdon, which is about five miles distant.† There are two Inns in the town, the Crown

* See Geological Map of England.

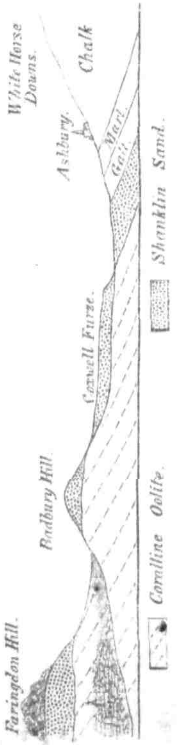
† As there is not a conveyance from Farringdon to meet every train that stops at the station, the visitor who objects to a long walk should previously ascertain the time when the omnibus or coach does arrive, and select a train accordingly.

and the Bell, where comfortable accommodation may be obtained.

The town is situated in a valley, between Farringdon Hill, an eminence seen from a considerable distance in the approach from Oxford, and Badbury Hill (see *Lign.* 269). A small stream divides the town into two tithings, called Port and West-port, and flows into the Thames on the north. The summits of the highest eminences near Farringdon consist of beds of sand and gravel, resting on Coral Rag and Kimmeridge Clay, and belonging to the Cretaceous formation, being the littoral deposits in this area of some sea of that period. The Lower Green or Shanklin Sand, the Galt, Chalk-marl, and Chalk successively appear in the valley below Coxwell Furze up to the White Horse Downs.

I have not observed any organic remains in the strata on the top of Farringdon and Badbury Hills, but from the pits in the low country numerous fossil sponges and other *amorphozoa* (see pp. 227—229) may be obtained. One of the most productive "gravel-pits," as they are here termed, is situated on the road to Little Coxwell, about three quarters of a mile from Farringdon. It lies on the left of the road leading to the pretty village of Shrivenham. In this pit, the strata consist of a coarse aggregate of siliceous particles, with some lenticular masses in the state of compact conglomerate; the lower beds are of a whitish grey, the upper of a deep ferruginous colour. The Windmill public-house, close by, is kept by the owner of the pit (*Panting*), and specimens of the "petrified salt-cellars" (see p. 228) and other sponges may generally be obtained of the inmates; but the collector, in a few hours, will be able to gather an extensive and interesting collection; the pick-hammer, *Lign.* 266, *fig.* 2, will be found the most convenient instrument. There are two other pits within a moderate distance of Panting's pit, which are also rich in fossils. The principal

organic remains to be obtained from these beds are the zoophytes figured p. 227, and *Wond.* p. 637. The reader



LIGN. 269. SECTION OF THE STRATA AT FARRINGDON, BERKS; from FARRINGDON HILL to the CHALK DOWNS on the South.

The summits of Farringdon and Badbury Hills, and Coxwell Furze, are formed of sands and gravels of the Cretaceous period. The lines on the Coralline Oolite are not intended to denote the dip of the strata.

NOTE.—See Memoirs on the Farringdon Sands, by Mr. R. A. C. Austen, in *Quart. Geol. Journ.* vol. vi. and by Mr. D. Sharpe, *ibid.* vol. x.

should recollect that the beautiful cup-shaped sponge, *Chenendopora fungiformis* (*Lign.* 71), is the "*petrified salt-cellar*" of the quarrymen. As many specimens as possible of the interesting coral, *Verticellipora* (p. 227, *Lign.* 70, *fig.* 4,) should be procured, to examine the internal struc-

contain vestiges of the soft bodies and arms (see page 459, and *Lign.* 145).

CALNE, about six miles from Chippenham, stands on Oolitic limestone; and the quarries around the town have long been celebrated for the perfection and abundance of their fossil remains; particularly of various species of the turban echinites (*Cidarites,* see p. 316), and their spines. A day or two at each of these towns will be well spent by the geologist and the collector of organic remains.

BATH AND BRISTOL.—The immediate vicinities of these cities are rich in interesting localities for the geologist. A visit to the public museums in Bath and Bristol cannot fail to gratify the student, and will at once point out to him the places most worthy his examination. That of Bristol is admirably arranged, and contains, among other treasures, the specimen of fossil *Squaloraia* (see p. 596); the remains of the reptiles of the magnesian conglomerate, the *Thecodontosaurus* (p. 713); and the celebrated collection of Crinoidea (p. 283) formed by the late Mr. Miller.

CLIFTON.—The stupendous rocks of mountain limestone which flank both sides of the Avon in its course from Clifton to the Severn are too well known to render a general description necessary, and our limits will not admit of details. The geological student should first obtain a *coup d'œil* of the appearance and position of the strata, by sailing down to the embouchure of the river in a steam-packet, and afterwards visit on foot the most interesting localities. On the right bank of the river, near the "Black Rock," the teeth of several kinds of fishes of the genera *Psammodus* (p. 587), *Hybodus* (p. 591), *Ceratodus* (p. 587), &c. may be obtained, and shells and corals of the mountain limestone. Polished specimens of the coralline marbles may be purchased at the shops.

Portishead, a pretty little village on the south-east bank of the Severn, is well worth a visit; and, by going in the

morning steamer and returning in the evening, several hours may be agreeably spent along the shore below the hotel; and fossil plants and shells, from the blocks of mill-stone grit, and numerous rock specimens may be collected.

A sail to *Chepstow*, and up the Wye as far as Tintern Abbey, returning on foot, or in a carriage, by Piercefield to Chepstow, is an excursion replete with the highest interest and enjoyment. The picturesque beauties of the Wye are dependent, like those of Clifton and Matlock, on the disruptions which the strata of mountain limestone have sustained. The magnificent scenery as we pass up the river, and the interesting associations connected with the ruins of Tintern Abbey, cannot fail to delight the traveller; but the enchanting scene that bursts upon the sight from the heights of Piercefield is magnificent in the extreme, and equal to the grandest views on the Rhine. Looking down from those elevated pinnacles of rock, which are covered with the most luxuriant vegetation, and crested with forests of pine, oak, and beech, we perceive the Wye pursuing its tortuous course at our feet, and winding along, around promontories of limestone, towards Chepstow; while immediately beyond, and apparently separated from the opposite bank of the river only by a precipitous rampart of mountain limestone, the Severn appears as a vast inland sea, bounded in the remote distance by the country around Gloucester, and extending on the right to the Bristol Channel.

Among other interesting geological sites within a few miles of Clifton and Bristol, may be mentioned—

1. Aust Cliff; a section of the Lias, from which many interesting fossils have been procured.

2. Banwell Cave; which is particularly deserving of examination (see p. 809).

3. Cheddar Cliffs; which are equally interesting to the

geologist and to the lover of picturesque scenery. They are about twenty miles from Bristol; and a carriage and pair will be required, if the visitor intends to return the same day. The best arrangement is to visit the cavern at Banwell, remain in the neighbouring town the following night, and make an excursion to Cheddar Cliffs the next day.

There has lately been opened at Cheddar a cavern which surpasses in the beauty of its stalactites any hitherto discovered in England. The Rev. W. D. Conybeare states, that it is the only one that at all realizes any idea we have of the far-famed *Grotto of Antiparos*. It consists of one grand arch, or porch, and three or four lateral branches and narrow fissures, about ten or twelve feet broad, and from thirty to forty feet high, vested and draped with the most fantastic hangings of stalactite. The floor is a mass of stalagmite, covering a bed of gravel of the mountain limestone, which fills up about ten feet of the bottom. I am not aware that any fossil bones have been observed.

When visiting Banwell, inquiry should be made if there be any Cave at Hutton accessible to the visitor.

The above remarks must be regarded only as suggestions; for it would require a volume to particularize the geological objects of interest within a short distance of Bristol. The coal-mines in the neighbourhood of Bath and Bristol should be visited, and fossil plants collected.

CHAPTER XXIV.

GEOLOGICAL EXCURSION TO MATLOCK.

———— "In famed Attica such lovely dales
Are rarely seen: nor can fair Tempè boast
A charm they know not."

LORD BYRON.

THE beautiful and romantic Dale of Matlock, although one hundred and forty-two miles distant, is now brought within nine hours of the metropolis. Leaving London from the Euston-square station of the Birmingham Railway, at eleven o'clock (taking the precaution to have a ticket that will ensure a passage from Rugby by the *Midland* Counties Railroad to Derby), we pass over in succession the clays, sands, and beds of gravel, composing the *Tertiary* strata of the London basin; and at Watford, steep cuttings of these deposits are seen on each side of the station. A long tunnel through the *White Chalk* of Hertfordshire is then passed; and at Tring we arrive at the termination of the Chalk, and obtain a fine view of the north-west escarpment of the Downs, which is seen extending on the right towards Ivinghoe, and attaining an elevation of 900 feet. The railway then proceeds over the Chalk-marl, Galt, and Lower Green-sand, to near Leighton, where these members of the Cretaceous system are succeeded by the *Oolite* of Buckinghamshire and Northamptonshire; and the line crosses the Grand Junction Canal near the emergence of the *Lias*; the Rugby station being situated in the midst of

that formation. We then enter the Midland Counties line, and pass on to Stoney Stanton, where the Lias terminates, and the *Triassic* or *New Red* strata appear; proceeding towards Leicester, clays and marls of a dull red colour, denoting the Triassic deposits, constitute the slopes on each side the railway. As we approach Leicester, the craggy summits of Charnwood Forest appear in the distance on the left, with here and there an isolated conical hill, indicating the protruded masses of granite, porphyry, and syenite, which belong to the group of plutonic rocks of the central county of England. The granitic mass of Mount Sorel is seen along the railway from Sileby to Barrow, Charnwood Forest appearing in the distance.

Leaving Leicester for Derby, the route continues along Triassic strata; and a good section of the variegated marls, with veins of white fibrous gypsum, may be observed at *Red Hill*, where a short tunnel perforates a ridge of the same deposits. The railroad then emerges on the verdant alluvial plain through which the Trent, its waters increased by the confluence of the Dove and the Soar, pursues its course towards the north, and joins the Humber at Alkborough, whence the united streams flow on, and empty themselves into the German Ocean.

At Derby, where the train arrives at half-past five, half an hour is allowed for dinner; and we then proceed by the *North Midland* line, by Duffield and Belper, through a beautiful valley watered by the Derwent, which is seen winding its way towards Derby. The high grounds skirting this valley are composed of the millstone-grit and sandstone of the Carboniferous system (see p. 31). Ten miles beyond Derby, we arrive at Amber Gate station, where an omnibus and other conveyances are in waiting, to convey passengers to Cromford and Matlock.*

* As it frequently happens that more passengers are brought by the train, than the omnibus or coach can convey, some activity is

The road from Amber Gate leads through a succession of picturesque scenes of surpassing beauty. At Whatstandwell-bridge * (see *Lign.* 273), over which the Derwent is crossed, the view is most imposing. The river is seen rapidly pursuing its course between richly wooded ravines, fringed with luxuriant foliage to the water's edge.† As we advance, the bold mountain ridge of *Crich Hill* appears on the right, with the village of Holloway at a considerable elevation, and Lea Mills near the base of the range; while on the left are the hills and overhanging woods of Alderwasley. Ascending to the Inn at Cromford, the road turns suddenly to the right, and by an opening cut through a mass of strata twenty feet thick, called *Scarthing Rock*, conducts to the southern entrance of Matlock Dale. On passing this chasm, the glorious features of this enchanting region burst on the view. On the east is a range of limestone cliffs, richly wooded, with Willersly Castle, the seat of the Arkwrights, embosomed in trees on a commanding eminence; and on the west, a rocky precipice, crested with forests, and its sides partially covered with copses and brushwood; while the river, dashing through the ravine on the right, completes the magic of the picture—

> " So wond'rous wild, the whole might seem
> The scenery of a fairy dream."
>
> LADY OF THE LAKE.

At the distance of about half a mile, we pass the toll-gate, and a bold mural precipice of mountain limestone suddenly

necessary to secure an outside place, which it is most desirable for the geological tourist to possess, that he may command a good view of the splendid scenery, which will be constantly opening on his sight, through the romantic pass that leads to Matlock.

* HOTSTANDWELL in the guide-books; *Whatstandwell* in the Ordnance Map.

† The pedestrian should alight at the little Inn at Whatstandwell; and walk on to Matlock the following morning.

appears on the eastern bank of the river; while on the western, a steep slope, clothed with verdure, rises rapidly to the lofty pine-clad eminence called MASSON HILL, an elevation of upwards of 1,000 feet. The base of this mountain stretches directly across the dale in front, and apparently presents a barrier to an egress from the valley on the north; but as we advance, the road is seen to wind round its foot by a defile along the left bank of the river; and the magnificent rock called the HIGH TOR rises in majestic grandeur on the right. The valley now gradually expands, and, at the distance of about two and a half miles from the entrance at Scarthing's rock, terminates in the champaign country beyond Matlock village.* From the precipitous nature of the escarpment of mountain limestone which forms the eastern boundary of the dale, the buildings at Matlock Bath are confined to the left or western side of the Derwent, and are scattered here and there among the trees, on the projecting plots and terraces formed by the fallen cliffs of sandstone, which, during the lapse of ages, have become partially disintegrated and are more or less concealed by vegetable soil; the projecting rocks are covered with lichens, mosses, and ferns.

The hotels, of which there are several, are all delightfully situated; but the *Temple Hotel*, which stands on a terrace on the side of Masson Hill, about a hundred feet above the river, has the preference in my estimation; its elevated situation, its seclusion from the noise and bustle of the village, and its bowers and hedge-rows of sweet-briar and roses, imparting a character of sylvan beauty to the spot, peculiarly grateful to the traveller who wishes to enjoy a quiet sojourn at Matlock Dale. The local guide-books afford the necessary information to direct the visitor to the celebrated picturesque spots of this beautiful region; our

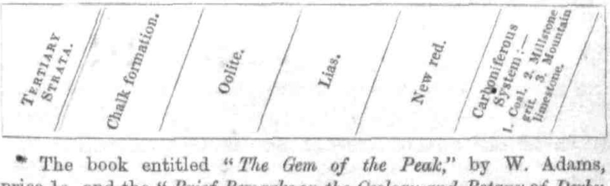
* The proper name of the hamlet in the valley, generally called Matlock, is *Matlock Bath*.

immediate object is to point out the most important geological phenomena.*

GEOLOGICAL POSITION OF MATLOCK DALE.—That the reader may clearly comprehend the geological character of the romantic district in which he is now situated, we will briefly enumerate the several formations over which we passed, in our rapid transit from London; by the aid of the geological map, the following description will be easily comprehended.

Our route from the metropolis commenced from the centre of the *Tertiary* strata, upon which London is situated, and which fills up an extensive depression or basin in the Chalk; we then passed over, or rather (by the tunnel) through the north-west boundary of the *Chalk* basin, and successively came upon the *Portland* stone and other beds of the *Oolite*, and the *Lias;* the strata of these formations successively rising from beneath each other as we proceeded. In Leicestershire, the beds of the *New Red* or *Triassic* formation emerged from under the Lias; and at the Trent Junction the nature of the deposits was concealed by the alluvial plains of the river. Beyond Derby, we entered upon strata of the *Carboniferous* system, the *Millstone grits* and *sandstones*, and finally reached the *Mountain limestone* and its associated *Magnesian limestones*, which compose the mountainous district of Derbyshire. The following diagram will serve to illustrate this description.

London. *Matlock.*



* The book entitled "*The Gem of the Peak,*" by W. Adams, price 1*s.*, and the "*Brief Remarks on the Geology and Botany of Derbyshire,*" by the same author, price 1*s.*, will be found to contain much

The immediate vicinity of Matlock is, therefore, a region of Carboniferous limestone and millstone strata, which, as we have previously explained (see p. 31), are of marine origin; and those beds that contain organic remains abound in extinct species of shells and crinoidea. These rocks are also the grand depository of the ores of lead (see *Wond.* p. 681), calamine, &c., and contain a variety of minerals of great beauty and interest. This district has also been the theatre, in very remote periods, of great physical changes, and the strata have been upheaved and displaced by volcanic action, the solid rocks rent asunder, and beds of mineral substances, rendered fluid by intense heat, have been injected between the layers, and into the fissures of the sedimentary strata; to these revolutions, the present bold and picturesque features of the country are attributable. Here then are phenomena replete with the highest interest; the very beds of lava may still be seen—the rents and fissures caused by their explosive action, and now lined with rich metallic ores and spars, may be examined—and the thermal waters, rising in perpetual fountains from an incalculable depth, testify that the internal fires, the sources of these catastrophes, though latent, are not extinguished.

A WALK TO THE INCRUSTING SPRINGS.—The so-called "petrifying springs and wells" of Derbyshire are celebrated throughout England for the incrusted birds' nests, baskets, &c. which are very generally purchased by visitors, as mementos of a trip into this county. The nature of this deposition of calcareous matter has already been explained (see p. 39; and *Wond.* p. 75); and, although the objects above mentioned are scarcely worthy of notice, the natural operations by which the tufa and travertine are produced, are extremely interesting.*

valuable information. The "*Derbyshire Tourist's Guide,*" with plates, 8vo., by E. Rhodes, price 6s., is a delightful hand-book.

* If the proprietors of these springs could be induced to follow

Our first stroll shall therefore be to the beds of tufa which have been formed in remote ages by this operation, and which now constitute the terrace on which the Old Bath and two other hotels, and the elegant modern Church are situated. Proceeding from our Inn, the tufaceous rock may be seen protruding in masses on the right hand, in front of the beautiful parterres of the hotels; and upon crossing the road, where a narrow path leads down to the bed of the river, and nearly opposite to the new church, the lower beds of tufa are exposed in a quarry, from which large blocks of the coarse, porous stone are extracted for grotto and rock-work. From this spot I collected very fine impressions of the foliage of the oak, elm, and hazel, leaves of adder's tongue (*scolopendrium*), &c. and large portions of moss, beautifully incrusted.*

The origin of this deposit of tufa, which covers so large an area along the western flank of the mountain range of Masson Hill, is attributable to the thermal springs having, at some very remote period, issued from a much higher source than at present, and flowing down the side of the hill, into the river at its foot, the water, as it cooled, deposited the lime with which it was charged on the stems, branches, leaves, and other extraneous bodies. At this time the springs escape from crevices in the rocks at an elevation of about one hundred feet above the bed of the river; the waters, at their source, have a temperature of from 66° to 68°, and contain free carbonic acid and minute quantities of muriates and sulphates of magnesia, lime, and soda.

the example of the Italians at San Filippo (see *Wond.* p. 75), or of the French, in Auvergne, or the Germans at Carlsbad, elegant bas-reliefs and other beautiful objects might be obtained, for the incrusting power of the Matlock waters is very considerable.

* I could not obtain any specimens of this kind from the quarry-men, nor from the shops or museums, as they are termed; such objects not being deemed "curiosities" by the good folks of Matlock; and the workmen forbade me to search for more in the quarry!

Their origin is now concealed, and the water conducted by pipes to the various baths and fountains; but wherever a rill escapes, and flows down the hill, the moss, &c. is quickly incrusted. I was informed, that in about eight months a basket of eggs would be entirely enveloped in a thick mass of tufa. The uniform high temperature of these waters shows that they emanate from a very deep source; and it is probable that they originate from steam, which is cooled and condensed as it approaches the surface of the earth. The miners assured me, that the springs burst out from beneath the volcanic rock, here termed *toadstone*, and that the water, when it first issues, is of a higher temperature than the Matlock Bath water; but its heat is reduced by the cool land-springs with which it becomes intermingled.

Most waters that flow through limestone districts deposit travertine more or less abundantly; and I observed several streams in my rambles in the neighbourhood of Matlock which appeared to possess this property in as great a degree as the thermal springs. There is a lovely waterfall, which issues from the side of a mountain that flanks the road leading by Via Gellia to Middleton Moor, at an elevation of two hundred feet, and flows into the adjacent valley, bounding and dancing from one mossy knoll to another, and appearing from the opposite hill like a stream of molten silver, undulating through a carpet of emerald green. The waters of this cascade have formed a thick bed of travertine along the side of the hill; and the stone is of so firm a texture, that the walls of a cottage hard by are constructed of it. I gathered from the banks of this waterfall, bundles of moss and groups of small shells incrusted with a beautiful white tufa; and impressions of leaves, twigs, &c. were observable in the blocks of travertine recently quarried.

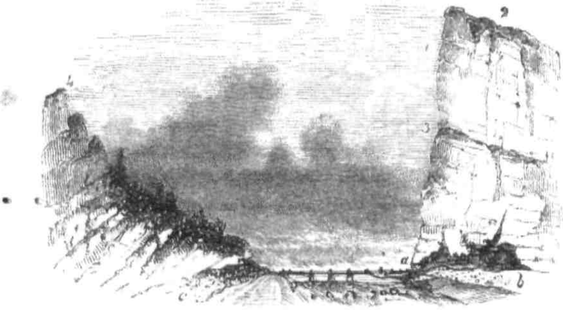
In contemplating the effects produced by these limpid streams, by which perishable leaves and fragile shells are preserved for ages in solid masses of rock, we are reminded

of the forcible and eloquent remarks of Sir Humphry Davy, when observing similar phenomena in the volcanic regions of Italy. "How marvellous are those laws, by which even the humblest types of organic existence are preserved, though born amidst the sources of their destruction; and by which a species of immortality is given to generations, floating, as it were, like evanescent bubbles on a stream raised from the deepest caverns of the earth, and instantly losing what may be called its spirit in the atmosphere!" *

VISIT TO THE CAVERN OF THE HIGH TOR.—After the visitor has taken a general view of the romantic scenery around him, a visit to the cavern at the foot of the High Tor will enable him to comprehend the nature of those physical changes which have imparted to this district its picturesque character. Descending into the valley, and passing northwards, through the only street in Matlock Bath, along the banks of the Derwent, which are beautifully overshadowed by copses and forest trees, the bold cliff of mountain limestone, called the High Tor, the most imposing feature in the dale, suddenly appears on the right bank of the river. This rock rises to the height of four hundred feet; the upper half forming a bare and nearly perpendicular wall of limestone; the lower portion being concealed by brushwood and luxuriant foliage to the river's edge. At this spot, a rude wooden hand-rail is stretched across the Derwent, which is here of considerable breadth, and dashes along over fallen masses of rock in its course towards the south. The High Tor (*Lign.* 270) consists of a capping of Drift and of Millstone grit (2); of a series of beds of limestone with encrinites and shells, slightly inclined southward (1); of a layer of volcanic matter, termed in Derbyshire *toadstone*, from its mottled yellow and greenish appearance (3); and of a bed of *Trap*, or *toadstone* (*b*), at the base, and

* "Consolations in Travel; or, the Last Days of a Philosopher;" by Sir Humphry Davy. See also *Wond.* p. 77.

near the floor at the entrance of the fissure or excavation in the limestone forming the cavern (*a*); which trap rock also appears on the opposite bank of the river (*c*), beneath the highly inclined and dislocated masses of limestone, forming



G. A. M. delt. *J. Whimper, lignt.*

LIGN. 270. SECTION ACROSS THE VALLEY OF THE DERWENT, AT THE HIGH TOR, MATLOCK.

1.—The HIGH TOR, composed of strata of MOUNTAIN LIMESTONE.
2.—Capping of MILLSTONE GRIT and DRIFT.
3.—Supposed position of an intrusion of TRAP.
4.—Cliff of limestone on the opposite side of the valley.
a.—Entrance to the *High Tor* Cavern.
b.—*Trap* seen at the bottom of the Cave.
c.—*Trap* beneath the limestone on the opposite bank of the Derwent.

part of the base of Masson Hill. The upper bed of *toadstone* (3) cannot be seen, for the face of the cliff (although represented bare for the sake of perspicuity in the plan, *Lign.* 270) is entirely concealed, half-way up, by dense foliage; but an intelligent miner assured me that such was the fact, and that, in sinking a shaft in the opposite hill, *toadstone* was found in a corresponding situation. Upon entering the cavern, which is not of considerable extent, the first phenemenon to be observed is the bed of *toadstone*,

which protrudes near the floor, beneath a stratum of limestone. The limestone in contact with the trap is in some places changed to a light green colour, and has a slaty texture, from the effects of intense heat under great pressure; it is often permeated with veins of pyrites, and white calcareous spar. The inner recesses of the cavern are literally covered, both on the floor and sides, with very large rhomboidal crystals of carbonite of lime, of the form commonly called *dog-tooth spar;* the cave surpasses, in this respect, every other in Derbyshire.

Within a few hundred yards of the cavern, a gallery has been driven into the cliff, and a vein of lead (*galena*) discovered, and worked with some success. Fine masses of blue fluor (provincially termed *blue John*) and double refracting calcareous spar were also obtained. On the opposite bank of the Derwent, beneath the limestone, and extending along the road-side for two or three hundred yards, a bed of *toadstone*, evidently the continuation of that at the base of the High Tor, is distinctly exposed.

Proceeding northwards, the line of mural precipices, of which the High Tor is the most elevated point, gradually descends; but there is a bold and bare rock, called the Church Tor, from the church of the village of Matlock being situated near its summit, that requires particular remark; for on the face of this cliff the strata present a series of curves, or rather arches, nowhere broken, but having such an appearance as would result from an expansive force from beneath uplifting a group of horizontal strata, while yet in a soft or plastic state. The upper beds of limestone at the Church Tor abound in marine shells (*Spirifer*, see p. 390, particularly the large species, *S. giganteus*). Such are the appearances presented by the strata in this locality, on the right bank of the Derwent. On the opposite side of the valley are beds of limestone, many of them varying in mineral constitution from those we have examined, being of a light

yellowish dun or cream colour (hence called *Dun-stone*), and containing magnesia; in these strata traces of fossil plants are occasionally found. These magnesian limestones are of a granular texture and extremely hard; they are said to be very rich in lead and calamine, and have been extensively worked. The prevailing rocks on this (the western) side of the valley belong to this group.

GEOLOGICAL FORMATIONS OF DERBYSHIRE.—Before we proceed on our walk, let us sit down awhile on this mossy bank, beneath the magnificent knoll of trees that here overshadows the river, and, by a reference to the geological table (p. 31) and the geological map, obtain a clear idea of the nature and succession of the strata around us; in other words, the order of superposition of the deposits of Derbyshire.

1. *Lowermost.* A bed of compact BASALT or TRAP (in Derbyshire called *Toadstone*), of uncertain thickness and extent. This rock consists of mineral matter that has undergone complete fusion, and been erupted from the profound depths of some internal source of intense heat (see *Wond.* pp. 684, 848). The upheaving force thus put in action having been unequally exerted in different places, the superincumbent beds of limestone have been protruded in dome-shaped masses through the upper strata; and are now seen bent and curved, forming what is termed arched stratification.*

Vesicular or *amygdaloidal* Toadstone. This partakes more of the character of *scoriæ*, being full of little cells or cavities formed by air bubbles; when these cavities are filled with other mineral matter, as is often the case, the rock is termed amygdaloidal. This bed of Trap was formerly considered to be distinct from the lowermost; but it is now supposed, and with much probability, that all the masses of igneous rock that pierce, or are intercalated with, the sedimentary strata, have sprung from one common source, and are but lateral protrusions from some grand mass of erupted materials.†

* My excellent friend, the late Robert Bakewell, Esq., was the first geologist who correctly explained the phenomena here described. See his Introduction to Geology, 5th edit. p. 147.

† See an analogous example, *Wond.* p. 857.

2. LIMESTONES with intervening layers of clay, and Magnesian limestones, or Dunstones.

3. Alternation of LIMESTONE and SHALE. Many of these limestones abound in organic remains; and it is in this group that the ornamental marbles of Derbyshire are comprised. The upper beds are generally of a slaty texture, and contain layers and nodules of chert, which often afford exquisite siliceous casts of the stems of *Crinoidea* (pulley-stones, see p. 284; and *Wond.* p. 650), and shells; white chert or porcelain-stone, and black jasper or flinty slate also occur in these beds.

4. MILLSTONE GRIT and SHALE, and coarse sandstones; these form the subsoil of the principal heights of the mountain ranges, their sterile soil supporting only a covering of ling and heath.

5. COAL MEASURES; consisting of beds of Coal, with intervening layers of shale, clay, and ironstone (see p. 80).

6. PERMIAN and TRIASSIC strata (see pp. 29, 30).

The mineral substances found in the above strata in Derbyshire are very numerous, and the organic remains equally so, and of a highly interesting character.*

This enumeration of the geological formations of which the country around Matlock is composed will enable us to proceed on our rambles without further digression; and should the reader be at a loss to comprehend the nature of any of the rocks or strata we may meet with on our way, he can refer to the above description.

Mr. Bakewell, with his wonted penetration, first detected the true character of the stratification of the High Tor, previous writers having described this cliff as being composed of nearly horizontal layers. But this is a deceptive appearance; for, although, when viewed in front, or in the direction of their planes, the strata appear to be horizontal, yet they are in reality highly inclined, as may be seen in the line of dip, and enfold or envelope the back of the cliff; and

* A good catalogue of the principal varieties will be found in Mr. Adams's pamphlet previously recommended; and specimens may be obtained at his museum in Matlock, and from Mr. Tennant (Professor of Mineralogy to King's College), 149, Strand, London.

they are continued into the hill (Masson) on the opposite side of the valley, where they present a similar arrangement. The continuity of the strata is broken by the vale of the Derwent, which has evidently originated in a fissure extending along the axis of elevation, in a direction from north to south; thus forming the water channel for the drainage of the country on the north, and the bed of the present river. We have already pointed out the curved position of the strata on the face of the *Church Tor*.

EXCURSION TO CRICH HILL.—The appearances observable at the High Tor are of so striking a character, and involve the consideration of so many interesting phenomena relating to the physical mutations which this district has undergone, that it is desirable, while they are strongly impressed upon the mind, to take an excursion to CRICH, a few miles to the south-east of Matlock. Here there is an entire mountain of limestone, formed by a protrusion of numerous strata, many hundred feet in thickness, through the once superincumbent beds of millstone grit and sandstone, into a dome-shaped mass, upwards of 800 feet high. And there it stands, a stupendous monument of one of the past revolutions of the globe, with its arches of rifted rock, supported by a central mound of erupted mineral matter, now cooled down into an amorphous mass of compact basalt! Were there no other object of interest near Matlock, Crich Hill would alone render it worthy of resort.

From the heights above our hotel, looking towards the south-east, a mountain remarkable for its elevation and obtusely conical configuration, and distinguished by a tower on the summit, forms a striking object on the horizon, at an apparent distance of three or four miles—this is CRICH HILL; and on the same range, to the right, is seen the church-spire of Crich village (see *Lign.* 272).

A long summer's day is not too long to visit this mountain, and examine all its interesting details. A good pedes-

trian should proceed with his hammer and haversack, for every step of the road is replete with interest; and as numerous specimens will be obtained, bags, paper, and boxes should be taken. If an invalid or ladies be of the party, it will be desirable to have a carriage for the day, and dine at the little village of Crich;* and, if time permit, the interesting ruins of South Wingfield Manor-House (once the prison of Mary of Scotland), about two miles from Crich, may also be visited.

The shortest drive from Matlock to Crich Hill is over Cromford-bridge; but a far more picturesque route is by the Derby-road to Whatstandwell-bridge (see *Lign.* 273), and from thence ascending the hill to Crich, and returning home by Holloway; making the entire distance about twelve miles. As our immediate object is to examine the geological features of the mountain, we shall proceed by the nearest road; and upon reaching Scarthing Rock, turn to the left, by Wellersley Castle grounds, having on the right a bold escarpment of mountain limestone, with layers of chert in nodules and amorphous masses. At Cromford Canal, the limestone suddenly terminates, and sinks beneath the surrounding alluvial silt of the river valley, and the millstone grit. We will chip off a few specimens of the chert, to examine at leisure. Crossing the bridge, the road winds round the foot of the hills of sandstone, which lie on our left, while on the right is the valley of the Derwent, and the river is seen here and there through openings in the copses and hedge-rows, meandering through the rich meadow-lands of the valley, which are flanked on the west by a magnificent range of lofty hills, clothed with the luxuriant woods

* A good guide will be a great acquisition, and save much time and trouble; and BENJAMIN FROGGATT, who has conducted Dr. Buckland and other geologists to the principal localities in the neighbourhood, will be found an obliging and intelligent attendant, perfectly conversant with the richest geological and botanical sites around Matlock.

of Alderwasley. The character of the scenery from this point of the road, till we ascend the high ground, is faithfully and graphically portrayed by MR. RHODES.*

"The road lies through a beautiful valley by the side of the Derwent; sloping meadows, crowned high above with a long range of magnificent woods, skirt the road-side on the left: on the right the river, pursuing its winding way beneath the umbrageous branches of oak, ash, alder, hazel, and sycamore, and bubbling as it passes along, is a beautiful object. About two miles below Cromford-bridge, the road leaves the more open part of the valley, and plunges into the thick woods that environ the little hamlet of LEA; a lovely spot, romantically situated by the side of a sparkling stream, in a deep hollow, amongst steep hills covered with foliage, and fields of the freshest verdure. The houses of this secluded village, with the exception of here and there a comfortable cottage, are handsome residences, nestling among orchards and parterres of flowers. Everything was flourishing most luxuriantly; and when we passed through the place, the hollyhocks, dahlias, and roses were in full blossom, and gave an extremely bright and cheerful aspect to the scene. The road continues through *Lea Wood* to *Holloway* by a very steep ascent, and from the toll-gate at the top of the hill it traverses the side of a mountainous ridge, covered with wood and intervening rock. The prospect is now magnificent: on the right a scene of great extent opens to the view, rich in all that constitutes the highest beauty in landscape. The summits of the two ranges of hills that form the eastern and western boundaries of the fertile valley at our feet are here from three to four miles apart; and the extent from north to south is from ten to twelve. Many minor eminences, rich with wood and intervening verdure, adorn this enchanting scene, through which the Derwent, sometimes hidden by overhanging trees, and sometimes sparkling with light, flows with busy speed and uninterrupted current by Belper, Milford, and Duffield, to Derby; the whole presenting an assemblage of splendid scenery finely diversified and rich in picturesque beauty. The woods of Alderwasley, that cover the hills from below Whatstandwell-bridge, to the dark pine-crowned eminenc of STONNIS, are peculiarly imposing and magnificent."

Near the village of Holloway there are several quarries opened on the side of the hill, which enable us to ascertain

* Derbyshire Tourist's Guide, p. 48.

that this range is composed of strata of millstone grit and sandstone, highly inclined and dipping from the hill. The beds are so split and shattered in every direction, that no large blocks can be procured, and the stone, although a good building material, is therefore only employed in the construction of the cottages and houses in the immediate vicinity. The *vignette* of this volume represents a mass of the inclined sandstone strata near this place. The reader will recollect that the hills on the opposite side of the valley, on our right, are also composed of similar strata; and that the ridge, covered with fir-trees, marks the bold escarpment of the millstone grit at STONNIS, over Cromford; so that the geological horizon of the valley, as seen from this spot, is wholly formed by the millstone grits and sandstones. A mile beyond Holloway toll-gate, the road turns to the left, and the bare dome of mountain limestone of CRICH HILL is before us. We soon arrive at a limestone quarry, in which the strata are seen to be distinctly arched (see *Lign.* 271, p. 886), as in the cliff at Matlock *Church-Tor.*

We will alight here to examine the rock more closely, and obtain specimens. Here we see that the strata are inclined both to the right and to the left, and also lean towards the central axis of the hill in front of us; presenting such an appearance as would be afforded by an excavation made in an onion, or other spheroidal body, formed of a series of concentric layers. The limestone in this quarry is of the usual subcrystalline character, abounding in shells, principally *Spirifer.* There are numerous vertical and oblique fissures in the rock, and these are more or less incrusted with minerals and spars, which have evidently been deposited by electro-chemical action, and admirably exemplify the manner in which the rich veins of lead, &c. are distributed in the strata of the interior of the mountain. In a crevice of the rock, in which the mineral contents were undisturbed, the arrangement of the

prevailing minerals of this part of Derbyshire, namely galena (*sulphuret of lead*), sulphate of barytes (here termed *cawk*), and fluor spar, was beautifully displayed. A layer of the blue sulphuret of lead, or galena, was spread over the surface of limestone forming the walls of the fissure; upon this was a thick stratum of white sulphate of barytes; and on the latter, fluor spar, of a light blue colour, forming cubic crystals on the surface nearest the cavity of the fissure, which therefore appeared to be lined with crystals of fluor.*

About half a mile beyond, we arrive at Wakebridge, near which there are several very productive lead mines. The "*Glory-mine*," one of the richest in Derbyshire, is said some ten years since, to have been worth from thirty to forty thousand pounds a-year.† A mining establishment on the left hand, where a powerful steam-engine is constantly at work, affords numerous specimens of the usual Derbyshire spars and minerals; and from among the heaps of refuse thrown by the visitor may make an interesting collection. *Near this spot, a vertical shaft was sunk in the* side of the hill, in search for lead ore, and at the depth of twenty fathoms, a rock of *compact Trap* was reached; the work was continued for a few yards deeper, but ultimately abandoned as fruitless. A gallery was subsequently driven into the side of the hill, lower down, and here, too, the trap was found; thus proving the existence of a central protrusion of igneous rock, over which the bent strata of mountain limestone are now disposed in consecutive layers. Numerous blocks of this compact trap or basalt, some of which are veined with red jasper, lie scattered about the site of the old shaft, and an interesting suite of specimens may be collected. Pursuing our way, the limestone strata

* The workmen at this and the other quarries generally have specimens of the fossils and minerals for sale, at moderate prices.

† Derbyshire Tourist, p. 50.

are seen in openings on the hill side, having the same remarkable arrangement as those before described.

Upon arriving where the road divides,* we must proceed on foot and visit the quarries, and examine the exposed masses of rock, that we may clearly comprehend the structure of the mountain. We will now ascend by the pathway that leads to the summit, and on the left several good sections of the strata are displayed. On reaching the tower on the crest of the mountain (*Lign.* 272, p. 887), a magnificent panorama bursts upon our sight; but which no language can adequately describe. Here and there bare pinnacles of rifted rock protrude through the green sward; and masses of white, yellowish, and pink sulphate of barytes, pyrites, fluor, and other minerals lie strewn upon the surface.†

Having reposed for some time at the foot of the tower to enjoy the glorious prospect spread around us, correct our notes, look over, trim, and wrap up our specimens, we will now descend to the north-eastern side of the hill, that the appearance of the strata on that aspect may also be examined. But ere we leave the summit, again let me call your attention to its external configuration. Were it not on too extended a scale, we might suppose that we were standing on an ancient earth-work, or encampment, formed of limestone, surrounded by a deep fosse or ditch, and flanked by precipitous embankments of millstone grit and sandstone, so strongly defined are the physical features of this remarkable mountain.

We will now visit a large quarry on the eastern side, which presents a fine section of the limestone strata, above 100 feet thick (see *Lign.* 271), and which, like those we

* The carriage should here be sent on to the village, and orders given for refreshments.

† Good specimens may often be obtained from the piles of stones, and from the walls on the side of the hill.

have previously observed, are disposed in curves, and enfold, as it were, the central axis of the hill; and the rock is shivered and fissured in every direction. A thick bed of

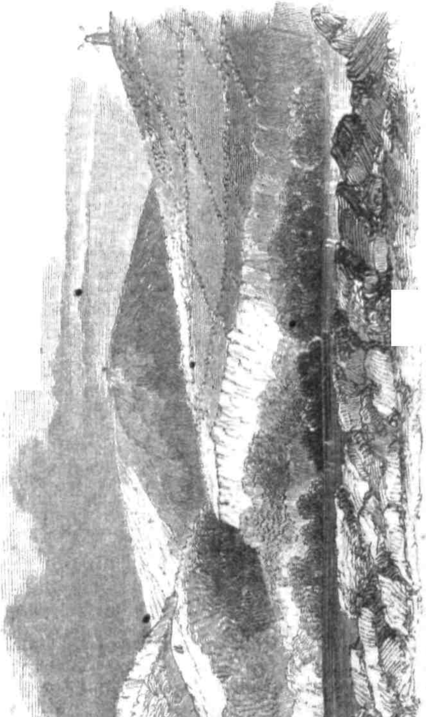
Henry Carr, Esq. C. E. del^t. *J. Whimper, lign^t.*

LIGN. 271. QUARRY OF MOUNTAIN LIMESTONE, CRICH HILL.

drift, or alluvial debris, covers the limestone strata, as shown in *Lign.* 271; and in it, partially rolled blocks of sandstone, some of them of great size, are imbedded. The

direction of the dip of the strata in this quarry is indicated by the arrows.

Let us now take a retrospect of the facts investigated



Drawn by Henry Carr, Esq. C. E. *J. Whimper, lign^t.*

LIGN 272. VIEW OF CRICH HILL, DERBYSHIRE, from the West.

during this morning's ramble, and consider how far Mr. Bakewell's interpretation of these phenomena (see p. 879) is in accordance with the data we have obtained. The

outline of Crich Hill, as seen from a moderate distance, is that of an insulated oblong dome, encircled by precipitous escarpments, or angular eminences of less elevation. The annexed sketch (*Lign.* 272), by my friend, Henry Carr, Esq. C.E., of Duffield, to whom I am also indebted for a survey of Crich Hill, and admeasurements of the dip of the strata, will render this feature in the physical geography of the country more apparent.

In *Lign.* 272, the protruded elongated cone of mountain limestone is denoted by the tower, or *Stand*, on the summit; and the other heights, and the foreground, are composed of millstone grit and sandstone. The highest point of limestone is 716 feet above the level of the Derwent in the adjacent valley; and was estimated by Mr. Bakewell at about 900 feet above the level of the sea. The hill of sandstone on the right, on which the mill stands, is 462 feet high, and conceals Crich village in this view; that in the middle distance, on the left, marked *a*, is 400 feet high.

This disposition of the millstone escarpments around the central cone of elevated limestone is shown more in detail in the ground-plan, *Lign.* 273.

Thus we perceive that the strata of mountain-limestone dip from the centre of the hill in every direction, as indicated by the arrows, at various angles, from 20° to 50°: and those of the sandstone hills, which form an irregular zone around Crich, are also highly inclined, and in like manner dip from the central axis, as is shown by the direction of the arrows. Now we know, by observations made in places where the relative position of the Millstone and Limestone has suffered no disturbance, that these two series of strata were originally disposed horizontally and conformably upon each other, thus—

1. *Uppermost*—MILLSTONE GRIT AND SANDSTONE.

2. *Lowermost*—MOUNTAIN LIMESTONE.

It is therefore evident, that at Crich the strata No. 2 must have been forced up, and protruded through the strata No. 1, or they could not occupy their present position.

LIGN. 273. GROUND PLAN OF CRICH HILL, Derbyshire.

(*Scale, one inch to a mile.*)

By HENRY CARR, Esq. C. E. from actual Survey.

The area, enclosed within a line, and marked *Stand, Crich Hill*, is the elevated oblong dome of *limestone*. All the surrounding country is composed of *millstone grit* and *sandstone*.

The arrows on the boundary line of Crich Hill denote the direction of the dip of the limestone strata in nine positions measured and determined by Mr. Carr. The dip varies from 20° to 50°; the greatest inclination is on the south-east of the tower.

The arrows on the surrounding millstone escarpments mark the dip of those strata in a sufficient number of stations, to convey a general idea of the position of the mountain masses environing Crich Hill.*

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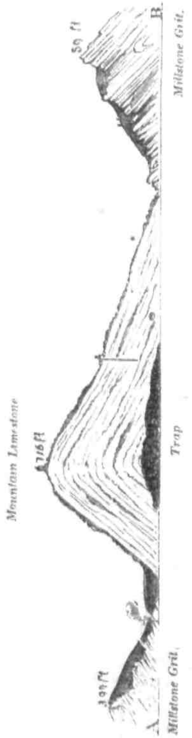
* At Whatstandwell, a bridge crosses the Derwent; and close by, there is the BULL Inn, where good accommodation and sleeping apartments may be obtained.

We remarked, on ascending Holloway Hill, the great disturbance which the Millstone beds had sustained (see the vignette of this volume); and the shaft and gallery near



LIGN. 274. SECTION OF CRICH HILL; from A to B on the plan, *Lign.* 273.

(*Natural scale.*)

BY REGINALD NEVILLE MANTELL.

A, B.—Strata of *Millstone Grit*, highly inclined, and dipping from the central axis.
Protrusion of Mountain Limestone, on the summit of which is Crich Tower, 716 feet above the level of the river Derwent.
Central mass of TRAP, reached by a vertical shaft from above, and by a gallery on the side of the hill.

Wakebridge (p. 884) disclosed the existence of a mass of basalt, or *trap*, of unknown extent, beneath the limestone, in the centre of the mountain; while the fissures and crevices, filled with metallic ores and spars, attest the

action of intense heat, under great pressure. According to a survey made by my son, a section in the line marked A—B on the plan, *Lign.* 273, presents the arrangement of the strata seen in *Lign.* 274 : the heights are from actual admeasurements.

From the data thus obtained, we may construct an ideal section in illustration of these phenomena, as in the following diagram (*Lign.* 275).

Here then, as Mr. Bakewell forcibly observed, "we have cause and effect in conjunction." Here is the cooled and consolidated molten rock, whose expansive force elevated the horizontal strata of limestone, and forced them through the superincumbent beds of grit and sandstone. But this eruption must have taken place under great pressure, and at the bottom of the sea; for, had the phenomena been sub-aërial, the result would have been altogether of a different nature; and we should have had cooled lava streams, and not masses of basalt.

We have seen that the strata rise round and enfold this central nucleus of volcanic rock, displaying nearly hemispherical segments and curves. Now if we suppose a vertical transverse fissure across such a hill as that represented in the diagram (*Lign.* 275), the face of the remaining strata would be in every respect similar to that of the High Tor (see *Lign.* 270, p. 876); namely, a mass of *Trap*, or *toadstone*, at the base, and a series of arched strata of limestone above; with fissures containing ores of lead, zinc, barytes, &c. and various kinds of spar.

To a mind accustomed to investigations of this nature, a slight examination of the phenomena under review will, I apprehend, suffice to demonstrate the correctness of these deductions; but I may have failed to place the subject before the general reader in an intelligible and lucid point of view; should this be the case, still, if the attempt to present a familiar exposition of the physical structure of

this remarkable district shall induce him to visit the scenes I have so imperfectly portrayed, and interrogate Nature in

LIGN. 275. IDEAL TRANSVERSE SECTION OF CRICH HILL.

A, A.—Highly inclined strata of *Millstone Grit.*
B, B.—Arched strata of *Mountain Limestone.*
C.—A central nucleus of *Trap* or *Toadstone.*

a right spirit, the hours we have passed together in our excursion to Crich Hill will not have been spent in vain; for in the beautiful language of the noble bard :—

"To sit on rocks, to muse o'er flood and fell,
To slowly trace the forest's shady scene,
Where things that own not man's dominion dwell,
And mortal foot hath ne'er or rarely been;
To climb the trackless mountain all unseen,
With the wild flock that never needs a fold;
Alone o'er steeps and foaming falls to lean;
This is not solitude; 'tis but to hold
Converse with Nature's charms, and view her stores
unroll'd."—CHILDE HAROLD, Canto II. xxv.

SPECIMENS OF FOSSILS AND MINERALS.—On our return, our first care must be to look over all the specimens we have gathered, arrange them, and select those which are the most illustrative of the phenomena we have examined; and ticket every specimen, as recommended in the Instructions. The fossils, consisting of several species of *spirifer* and other brachiopoda, and of portions of encrinital stems, require no particular care. The rocks should comprise specimens of the different varieties of limestone and sandstone; and of the green limestone, altered by contact with the toadstone; and examples of the compact trap, and of the variety veined with red jasper,—of the amygdaloidal toadstone,—and the vesicular, or that in which the cavities are empty. The minerals should comprise the ores of lead, zinc, barytes, fluor, and calcareous spar; of the last some good clear pieces should be selected, that will exhibit its double refracting property. Of the common metal, *Pyrites*, a few specimens should be preserved; this mineral, from its splendid yellow appearance, is often mistaken for gold; but a mere blow of the hammer will immediately detect it, for *Pyrites* is brittle, and readily cracks to pieces, while gold, as is well known, is remarkably ductile. If the collector be not satisfied with the fruits of his day's researches, he should look over the catalogue of Mr. Adams, and purchase such specimens as will render his collection sufficiently extensive to present a full illustration of the geological character of the scenes he has this day visited.

There is a variety of sulphate of barytes from near Youlgreave exhibited in the shops at Matlock, of which one or two examples should be obtained. The surface of the polished specimens much resembles the rich variegated appearance of dark tortoise-shell.

This mineral has been formed, like the common calcareous stalactite, by infiltration through some porous rock; transverse sections exhibit concentric layers of various shades; while the longitudinal have the varied colours disposed like those in tortoise-shell.

NOTES FOR A GEOLOGICAL EXCURSION BY CROMFORD, UP BONSAL VALLEY, BY VIA GELLIA, TO MIDDLETON MOOR; RETURNING BY STONNIS.

This excursion will present many objects of interest, and one day at least should be devoted to the examination of the different localities pointed out in the following notes.* To Cromford, and then take the road that leads through BONSAL vale. A fine range of limestone on the right, and a sparkling stream (Bonsal-brook) on the left. On the banks of this brook there is a manufactory of mineral colours (Pooley's) well worthy a visit. But before we reach this establishment, there is an opening on the hill-side where the strata are exposed, and a bed of Trap is seen beneath the limestone; near this place specimens of fluor, calc-spar, &c., that have been thrown out in forming the excavation, may be collected. From beneath the trap a warm spring issues and flows into the neighbouring brook.

Proceed up the road leading to *Via Gellia*, and through a valley flanked with high ranges of limestone and dunstone. On the right, is the beautiful cascade previously mentioned, near *Dunsley*. This valley is a celebrated botanical region, for several species of plants which are of great rarity or unknown elsewhere are here met with. At the direction post, turn to the left up the steep hill that leads to Middleton Moor. On each side numerous fossils

* Benjamin Froggatt should be engaged to conduct the pedestrian; and a carriage party would also do well to place themselves under his guidance.

of the mountain limestone may be collected from the blocks lying on the flanks of the hill. Views splendid in picturesque scenery and of a highly interesting geological character are obtained as we ascend. On the summit of Middleton Moor, which is from 1,300 to 1,400 feet above the level of the sea, a most extensive panoramic view of the surrounding country may be obtained. The geological map will enable the observer to identify the crags of Charnwood Forest, the High Peak, &c. &c. Almost every part of the Moor is studded with the disused shafts of exhausted mines, and which are so carelessly covered over as to be extremely dangerous, and the visitor must bear this caution in mind; for the heaps of stone placed at irregular intervals on the hill, and which tempt the geologist to seek for specimens, are for the most part piled over the openings of deep shafts.*

Pass on by Worksworth, to the quarries of mountain limestone, where the encrinital marble, so largely employed for side-boards, chimney-pieces, &c. is procured. Near the approach to the entrance of the quarry, an instructive example of curved strata of limestone is seen on the left; and on the right, a fine vertical artificial section. On the weathered surface of the left side of this entrance, and on the face nearest the quarry, good specimens of the stems and ossicula of the usual Derbyshire crinoidea may be extracted (p. 284) from the layers of reddish limestone; and good blocks of the marble may be selected. Large spirifers can be procured from the limestone in these

* My son narrowly escaped being drawn in by a heap of stones which gave way under his feet, and suddenly disappeared in the chasm below. In rambles of this kind in a mining country, the young geologist must, therefore, be upon his guard, or he may be engulphed with masses of limestone in some deep chasm, and his bones, incrusted with stalactite, form an ossiferous breccia, that in future ages may perplex some collector of organic remains to determine its relative antiquity!

quarries; the quarrymen often have specimens. On the right hand of the entrance, layers of flinty slate (called partings of *black bind* by the miners) occur between the beds of limestone. In a field near this quarry, on the left of the road leading to Cromford, where some mining operations are going on, blocks of the stone called *chert* have been thrown up, and often contain beautiful examples of the pulley-stones (p. 285), or siliceous casts of the stems of the crinoidea. A large collection of fossils may be gathered in the localities above mentioned.

We now drive to the escarpment of millstone grit at STONNIS, called *Black-rock*, whose pine-clad summit forms so conspicuous an object in the view from Crich Hill; it is about a mile from Cromford, and overlooks Matlock Dale. On the right of the road, the refuse workings of a mine cover the side of the hill; among which some specimens of spars or minerals may perhaps be found.

But the grand attraction of Stonnis is the view of Matlock Dale and the surrounding mountains, obtained from the verge of the precipitous escarpment of sandstone rocks, under the knoll of pines. It is, indeed, a scene of transcendent beauty and magnificence, and is said, by one who has ascended every mountain top and traversed every ravine and valley in this district, to be unrivalled.

"In that species of beauty which in landscape scenery approaches to grandeur, it is unequalled in Derbyshire. The parts of which it is composed are of the first order of fine things, and they are combined with a felicity that but rarely occurs in nature. Scarthing-Rock, the woods of Willersley Castle, Matlock High Tor, the hills of Masson, Crich, and Riber are all noble objects; and the rude masses that constitute the foreground of the picture are thrown together, and grouped and coloured in a manner strikingly picturesque. I have scaled the highest eminences in the mountainous districts of Derbyshire—seen from their summits the lovely dales that repose in tranquil beauty at their base—marked the multitude of hills included within the wide horizon they command, and my heart has thrilled with emotion at the sight; but not an eminence that I ever

before ascended—not a prospect, however rich and varied, which I thence beheld—is at all comparable with the view from Stonnis." *

Every one possessed of taste and feeling who gazes upon this glorious landscape will partake, in a greater or lesser degree, of the emotions thus finely expressed by the ardent lover of the sublime and beautiful in nature; but to the natural philosopher the physical characters of this enchanting region are fraught with a deeper interest, and present subjects for the most profound contemplation. To him the rocks and the mountains are the grand monuments of nature, on which are inscribed the history of the physical revolutions of the globe which took place in periods incalculably remote and long antecedent to the creation of the human race. They present to his mind a succession of events, each so vast as to be beyond his finite comprehension; ages of tranquillity, with lands and seas teeming with life and happiness, succeeded by periods in which the earthquake and the volcano spread universal ruin and destruction—and they teach him that all these awful changes bear the impress of the ALMIGHTY's hand, and were subservient to the eternal purpose of rendering this planet the fit abode of MAN, during his mortal pilgrimage.

* Derbyshire Tourist's Guide, p. 42.

CHAPTER XXV.

NOTES FOR A GEOLOGICAL EXCURSION TO CHARNWOOD FOREST, TO EXAMINE THE CENTRAL GROUP OF PLUTONIC ROCKS OF ENGLAND; AND THE CARBONIFEROUS AND CAMBRIAN STRATA, THROUGH WHICH THEY HAVE BEEN ERUPTED.

In the central county of our Island, within a hundred miles of the Tertiary deposits of the South-east of England, a group of plutonic rocks emerges from beneath the strata of limestone, coal, and red marl which constitute the principal geological features of the midland provinces, and rises up into the bold and picturesque range of hills of Charnwood Forest. Almost the entire series of British rocks is now brought by the railroads within a few hours distance of the metropolis; and the geological inquirer may, in the course of a fortnight, examine in their natural situations the Eocene deposits of the London and Hampshire basins—the Cretaceous and Wealden strata of Sussex, Kent, and Surrey—the Oolitic, Liassic, Triassic, Permian, and Carboniferous systems—the Mountain limestone and its metalliferous treasures—Traps, or ancient lavas, and their effects—strata of the Silurian and Cambrian systems—and, lastly, Granite, Syenite, Porphyry, and other modifications of the plutonic or igneous rocks. The present notes refer to two or three days spent in exploring the country around Leicester, and in examining the granite of Mount Sorel *—the slate quarries of Swithland—the syenitic crags of Bardon Hill—the porphyritic masses of Markfield and Grooby—and the

* Sorel, a corruption of *Soar Hill*, or hill on the river Soar.

coal-mines of Whitwick. On our previous excursion by railway to Leicester (see Excursion to Matlock, p. 867), the order of the succession of the strata from the metropolis to that town was described; on this occasion it will only be requisite to direct the traveller's attention to the abrupt isolated hills, by Hinckley, Grooby, and the craggy peaks of Charnwood Forest, in the distance, on the left of the railroad, before reaching Leicester. If a pedestrian excursion be resolved upon, three or four days at least will be required to follow the route presently pointed out; in a carriage and pair, it may be accomplished in a long summer's day, by starting from Leicester at six, and returning by ten or eleven.*

The geological localities to be visited in this excursion are the following:—

I. Barrow-on-Soar.† *Lias limestone*.—The quarries at this locality are celebrated for the organic remains that have from time to time been obtained from the limestone. Bones of Ichthyosauri and Plesiosauri (see p. 669), fishes (*Dapedius*, p. 603), leaves of cycadeæ, and fossil wood, together with ammonites, terebratulæ, &c. may generally be obtained.

Although at the very foot of the plutonic rocks, and on the verge of the grand focus of volcanic action which erupted the syenitic masses of Charnwood Forest, the strata in this spot appear to have suffered but little disturbance.

* It may be well to remind the visitor that at Leicester the following objects are worthy of notice:—the Roman Milestone, now placed in the High-street; the remains of the Roman Wall; and the Blue Boar Hotel, where Richard III. slept the night before the battle of Bosworth.

† There is a station at Barrow, and the pedestrian may be put down within a short distance, by the railway.

But this phenomenon is in accordance with what occurs in other volcanic districts. For, as M. Constant Prevost remarks, volcanoes may open across all the strata, without occasioning great derangements; thus, at Limagne, Aurillac, and Puy (see *Wond.* p. 269), the tertiary strata have preserved their horizontality, even around the vents through which issued the volcanic matter that covered those countries with numerous cones of eruption.

II. MOUNT SOREL. *Granite and Syenite.* — The road from Leicester ascends a ridge of Triassic or New Red strata, called Birstal Hill, from whence there is a fine view of the town. In the meadows on the left, some ruined walls, covered with ivy, mark the site, and are the only remains of the Abbey in which Cardinal Wolsey expired. Approaching MOUNT SOREL, an abrupt hill, with a mill on the summit, denotes, from a considerable distance, the geological character of the spot. There is a small Inn in the village, where accommodation may be procured. Visit the quarries, and also the establishment of Mr. Jackson, where the granite is worked into pillars, sideboards, &c.*

The hill is about 120 feet in height, and 1,400 yards long; and is estimated to contain about two hundred millions of cubic feet of workable granite, above the general level of the district.†

III. SWITHLAND. *Slate-rocks.*—From Mount Sorel proceed to Swithland: as we approach the quarries, the employment of slate for every available purpose, in the

* An interesting account of this manufactory will be found in Sir Richard Phillips's "PERSONAL TOUR."

† The granite resembles that of Aberdeen, but contains a larger proportion of felspar.

footpaths, walls of cottages, &c., indicates the abundance of this material in the neighbourhood. At Swithland, the quarries are very extensive, and expose magnificent sections, from 100 to 120 feet thick, of strata of Slate, highly inclined; and forming one side of an anticlinal axis, the summit of which will be passed over in our route by Woodhouse. In one quarry, at the time of my visit, a series of nearly horizontal strata of red marl was exposed, lying unconformably upon the edges of the highly inclined beds of Slate. The Slate-rocks of Charnwood Forest have a single anticlinal axis, which strikes from NN.W. to SS.E.; and the axis of the adjacent coal-field of Nuneaton has a similar direction.*

IV. Woodhouse. *Slate-rocks.*— From Swithland to Woodhouse, is a continuation of the highly inclined Slate strata. The village is romantically situated on the ridge or crest of the anticlinal axis of Charnwood Forest. On the sides of the road, there are occasional openings where the strata are exposed. There is, in particular, a fine section on the sides of the elevated point on which the church and school are built, lying to the left of the road in the approach from Swithland. A day might be well spent in this place, and at Swithland.

V. Bardon Hill. *Syenite.*—We next proceed to Bardon Hill, ascending to the highest ridge of the protruded mass of igneous rock, of which this mountain-range is composed. The craggy and bare pinnacles which are every where presenting themselves, shooting up, as it were, from the green sward, cannot fail, from their novel and striking character, strongly to impress the mind of the young geologist, who

* Murch. Sil. Syst. p. 569.

now, for the first time, visits a region of plutonic rocks. The view from the summit of the hill is grand and imposing; it should be studied with a geological map of the country before us, that the position of this central mass of volcanic rocks, and its relation to the surrounding sedimentary strata, may be fully comprehended.

VI. WHITWICK AND SNIBSTONE. *Coal-measures.*—Spread around the foot of the Syenitic mountain which we are descending are the coal-bearing strata of the Carboniferous system; and in the works at *Whitwick* and *Snibstone* the geological inquirer can examine the nature of these deposits in the coal-mines, which he should descend, and obtain specimens of the strata and fossils from the beds *in situ.**

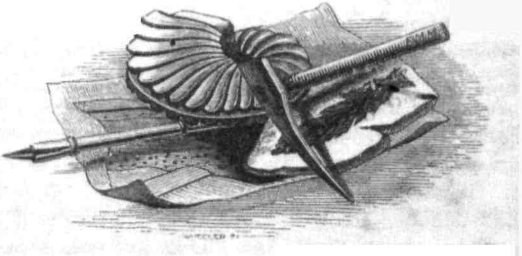
Among the refuse of the workings thrown up from the various shafts, search should be made for stems of *calamites* (p. 108), *seed-vessels* (p. 149), *fern-leaves* (p. 109), &c.

A section from Whitwick, through Charnwood Forest, to Barrow-on-Soar, in the direction of the route we have traversed, would give the following succession of rocks:— 1. Whitwick; *Coal-strata,* highly inclined. 2. *Slate-rocks* of Woodhouse, highly inclined. 3. Protrusions of *Syenite.* 4. *Slate-rocks* of Swithland, highly inclined, with unconformable strata of red marl. 5. *Granite* and *Syenite* Mount Sorel. 6. *Red marl* and *sandstone,* supporting the *Lias,* at Barrow-on-Soar.

* Should he be so fortunate as to see the resident engineer of Snibstone Colliery, Mr. George Vaughan, he will be certain of meeting with a courteous reception, and every facility for pursuing his inquiries, descending the shaft, and obtaining fossils. Mountain limestone is brought to this place to be converted into lime; and good specimens of shells, encrinites, &c. may sometimes be extracted from the blocks of stone.

The pedestrian should spend one or two days at Snibstone, where there is humble, but comfortable accommodation.

VII. MARKFIELD AND GROOBY. *Syenite and Porphyry*, &c.—These places may be visited on our way back to Leicester.



MISCELLANEOUS

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BRITISH NATURAL HISTORY SOCIETY, for the distribution of Fossils and Recent Shells, London Agent for the, 30, Tavistock-street, Covent Garden.

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CUTTELL, Mr., 52, New Compton-street, Lapidary. Prepares fossil teeth, &c. for the microscope.

DARKER, Mr., Lapidary, 9, Paradise-street, Lambeth. Fossil and recent objects for the microscope. Specimens of the infusorial earths, teeth of fishes and reptiles, marbles, &c.

EDWARDS, 40, High-street, Camden Town. For boards for cabinets, to affix fossils, shells, &c. instead of trays.

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SIMMONS, Mr., 6, Francis-street, Newington Butts. Collector of fossils; especially of choice Chalk fossils and fossil Foraminifera.

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fossils are described. The price of a mahogany cabinet with five trays, containing 200 specimens, illustrative of the elementary works on Geology, is five guineas: cabinets with fewer and less valuable specimens from two to three guineas. The following is an outline of the contents of the five guinea cabinet—

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BUY, WILLIAM; for Oxford Clay fossils of the greatest variety and in the highest perfection. Especially celebrated for his discovery and admirable development of the soft parts of Belemnoteuthides, Belemnites with phragmocones, &c.

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NOTES ON THE PRICES OF FOSSILS.—A short communication by the Author to Charlesworth's London Geological Journal, No. I p. 13, contains a list of the prices of several interesting fossils and collections of fossils.

MINERALS.—A complete series of the minerals of Cumberland comprising specimens of great beauty and interest, can be obtained of JOHN COWPER, Alston, Cumberland; he may be relied upon for his knowledge and attention, and his prices are moderate.

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